

SECTION 03100

CONCRETE FORMWORK

PART 1 GENERAL

1.1 WORK INCLUDED

- A. This item of work includes the formwork and shoring for cast-in-place concrete and the installation into formwork of items such as anchor bolts, pipe and pipe fittings, and other items to be embedded in concrete (but not including reinforcing steel - see Section 03200, CONCRETE REINFORCEMENT).

1.2 RELATED WORK

- A. Submittals: Section 01300.
- B. Concrete Reinforcement: Section 3200
- C. Concrete: Section 03300.
- D. Miscellaneous Metal Items and Fabrication: Section 05500.

1.3 QUALITY ASSURANCE

- A. Codes and Standards
 - 1. The Contractor shall design, construct, erect, maintain, and remove forms and related structures for cast-in-place concrete work in compliance with the American Concrete Institute Standard ACI 347, "Recommended Practice for Concrete Formwork."
 - 2. Tolerances for concrete construction and materials shall conform to ACI 117 "Standard Tolerances for Concrete Construction and Materials."
 - 3. PS 1 "Construction and Industrial Plywood"
 - 4. PS 20 "American Softwood Lumber Standard"
- B. Allowable Tolerances
 - 1. The Contractor shall construct formwork to provide complete cast-in-place concrete work as follows:
 - Raceways
 - a. Variation from plumb lines and surfaces: 1/8 inch per 6 feet, but not more than 1/4 inch overall. For exposed corners, control joints grooves and other conspicuous lines: 1/4 inch in 20 feet maximum; 1/2 inch maximum in 40 feet or more. Depressions in Wall Surface: Maximum 1/8 inch when 10-foot straightedge is placed on high points in any direction or at any

location. Wall Thicknesses: Maximum 1/8 inch minus or 1/8 inch plus from dimension shown.

- b. Variation from level or grade in slabs, and in arises: 1/4 inch in 10 feet, 3/8 inch in 40 feet or more. For exposed horizontal grooves and other conspicuous lines: 1/4 inch in 20 feet maximum and 1/2 inch in 40 feet or more. Slab Finish Tolerances and Slope Tolerances: Floor surface shall not have crowns so high as to prevent 10-foot straightedge from resting on 1/4-inch end blocks, nor low spots that allow a block of twice the tolerance in thickness to pass under the supported 10-foot straightedge. Finish Slab Elevation: Within 1/2 inch of elevation specified except slabs which are designed and detailed to drain to floor drain or gutter shall adequately drain regardless of tolerances. Repair floor slopes in an approved manner if necessary to provide complete drainage. Thickness: Maximum 1/4 inch minus or 1/2 inch plus from thickness shown.
Depressions retaining water are not allowed.

Other Concrete Work

- a. Variation from plumb lines and surfaces: 1/4-inch per 10 feet, but not more than 1/2 -inch. For exposed corners, control joints grooves and other conspicuous lines: 1/4 inch in 20 feet maximum; 1/2 inch maximum in 40 feet or more. Depressions in Wall Surface: Maximum 1/4 inch when 10-foot straightedge is placed on high points in any direction or at any location. Wall Thicknesses: Maximum 1/4 inch minus or 1/2 inch plus from dimension shown.
 - b. Variation from level or grade in slabs, and in arises: 1/4 inch in 10 feet, 3/8 inch in 40 feet or more. For exposed horizontal grooves and other conspicuous lines: 1/4 inch in 20 feet maximum and 1/2 inch in 40 feet or more. Slab Finish Tolerances and Slope Tolerances: Floor surface shall not have crowns so high as to prevent 10-foot straightedge from resting on 1/4-inch end blocks, nor low spots that allow a block of twice the tolerance in thickness to pass under the supported 10-foot straightedge. Finish Slab Elevation: Within 1/2 inch of elevation specified except slabs which are designed and detailed to drain to floor drain or gutter shall adequately drain regardless of tolerances. Repair floor slopes in an approved manner if necessary to provide complete drainage. Thickness: Maximum 1/4 inch minus or 1/2 inch plus from thickness shown.
- 2. Before concrete placement, the Contractor must check the lines and levels of erected formwork. The Contractor shall make corrections and adjustments to ensure proper size and locations of concrete members and stability of forming systems.
 - 3. During concrete placement, the Contractor must check formwork and related supports to ensure that forms are not displaced and that completed work will be within the specified tolerances.

1.4 SUBMITTALS

- A. Samples: Prior to start of work, submit one sample each as follows:

1. Form ties and all related accessories, including taper tie plugs, if taper ties are used.
2. Form Gaskets
3. Shop Drawings of form work of raceways with engineers seal ensuring forms will not deflect beyond the tolerances listed above. See Section 2.4.
4. Concrete installation sequence and schedule.

1.5 SEQUENCING AND SCHEDULING

Schedule work for embedded, buried, or other items of work that affects form layout before completing concrete formwork.

PART 2 PRODUCTS

2.1 FORMS FOR EXPOSED FINISH CONCRETE

- A. Unless otherwise shown or specified, the Contractor shall construct formwork for exposed concrete surfaces with plywood, plywood faced metal frames, steel or other panel type materials to provide continuous, straight and smooth as-cast surfaces. The Contractor shall furnish the forms in the largest practicable sizes to minimize the number of joints and to conform to the joint system shown on the construction documents. The Contractor shall provide form material with sufficient thickness to withstand the pressure of the newly placed concrete without bow or deflection. See **raceway structural drawings for raceway form requirements. Symons forms, or similar, will not be allowed on interior walls of raceways.**
- B. Except as otherwise expressly accepted by the engineer, all lumber brought on the jobsite for use as forms, shoring, or bracing shall be new material.
- C. Form materials which may remain or leave residues on or in the concrete shall be classified as acceptable for potable water use by the Environmental Protection Agency within 30 days of application or use.

2.2 FORM AND FALSEWORK MATERIALS

- A. Materials for concrete forms, formwork and false work shall conform to the following requirements:
 1. Lumber shall be Douglas Fir, construction grade or better, in conformance with U.S. Product Standard PS 20.
 2. Plywood for concrete formwork shall be new, waterproof, synthetic resin bonded, exterior type Douglas Fir or Southern Yellow Pine plywood manufactured especially for concrete formwork and shall conform to the requirements of PS1 for Concrete Forms, Class 1 and shall be edge sealed.
 3. Form materials shall be metal, wood, plywood or other approved material that will not adversely affect the concrete and will facilitate placement of concrete to the shape, form, line and grade shown. Metal forms shall be and approved type that will accomplish such results. Wood forms for surfaces to be painted shall be Medium Density Overlaid plywood, MDO Ext. Grade.

- B. Unless otherwise shown, exterior corners in concrete members shall be provided with $\frac{3}{4}$ inch chamfers. Re-entrant corners in concrete corners shall not have fillets unless shown otherwise.
- C. See raceway drawings for special raceway form material requirements.

2.3 FORM TIES

- A. The Contractor shall provide factory fabricated, adjustable length, removable or snap-off metal form ties with conical or spherical type inserts, designed to prevent form deflection and to prevent spalling concrete surfaces upon removal. Do not use wire ties.
- B. The Contractor shall provide ties so that portion remaining within the concrete after removal of exterior parts is at least 1-1/2 inch from the outer concrete surface except as otherwise specified. Form ties shall be provided which will not leave a hole larger than 1-inch diameter in the concrete surface. The holes shall be filled as per Section 03300, CONCRETE.
- C. Form ties and wire ties fabricated on the project site are not acceptable. Do not use wire ties of any kind. Ties shall withstand form pressures and limit form deflection to specified tolerances. Flat bar ties for panel forms shall have plastic or rubber inserts with minimum 1-inch depth and sufficient dimensions to permit proper patching of tie hole.
- D. Water Stop Ties:
 - 1. Provide for water-holding structures or dry structures with access such as basements, pipe galleries, etc., that are below finish grade.
 - 2. Ties shall have either an integral steel water stop 0.103-inch thick and 0.625 inch in diameter tightly and continuously welded to tie, or neoprene water stop 3/16-inch thick and 15/16 inch in diameter whose center hole is $\frac{1}{2}$ diameter of snap tie, or a molded plastic water stop of comparable size.
 - 3. Flat snap ties meeting these Specifications may be provided.
 - 4. Water Stop: Considerably larger in area than tie cross-sectional area, oriented perpendicular to tie and symmetrical about center of tie.
 - 5. Construct ties to provide positive means of preventing rotation or disturbance of center portion of tie during removal of ends and prevent water leaking along tie.
- E. Embedded Ties:
 - 1. Holes left by the removal of form tie cones shall be reamed with suitable toothed reamers so as to leave the surface of the holes clean and rough before being filled with mortar as specified for "Finish of Concrete Surfaces" in Section 03300 – Cast-in-Place Concrete. Wire ties for holding forms will not be permitted. No form-tying device or part thereof, other than metal, shall be left embedded in the concrete. Ties shall not be removed in such a manner as to leave a hole extending through the interior of the concrete members. The use of snapties

which cause spalling of the concrete upon form stripping or tie removal will not be permitted. If steel panel forms are used, rubber grommets shall be provided where the ties pass through the form in order to prevent loss of cement paste. Where metal rods extending through the concrete are used to support or to strengthen forms, the rods shall remain embedded and shall terminate not less than 1-inch back from the formed face or faces of the concrete.

F. Removable Ties:

1. Where taper ties are approved for use, the larger end of the taper tie shall be on the wet side of walls in water retaining structures. After the taper tie is removed, the hole shall be thoroughly cleaned and roughened for bond. A precast neoprene or polyurethane tapered plug shall be located at the wall centerline. The hole shall be completely filled with non-shrink grout for water bearing and below-grade walls. The hole shall be completely filled with non-shrink or regular cement grout for above-grade walls which are dry on both sides. Exposed faces of walls shall have the outer 2 inches of the exposed face filled with a cement grout which shall match the color and texture of the surrounding wall surface.

2.3 FORM COATING

- A. The Contractor shall provide commercial formulation form-coating compounds that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatment of concrete surfaces requiring bond or adhesion, or impede the wetting of surfaces to be cured with water or curing compounds.
- B. Form coating (nonstaining form oil) shall be equal to:
 1. Nox-Crete Company, Omaha, Nebraska.
 2. "Form-Guard," W.R. Grace and Company, Cambridge, Massachusetts.
 3. "Rheofinish," Master Builders, Inc.
 4. "Formcel," Lambert Corporation, Houston, Texas.

2.4 DESIGN OF FORMWORK

- A. The design of forms, shores, and bracing is the responsibility of the Contractor.
- B. The Contractor shall design, erect, support, brace, and maintain formwork so that it will safely support vertical and lateral loads that might be applied, until such loads can be supported by the concrete structure. Formwork shall be constructed so that concrete members and structures are of correct size, shape, alignment, elevation, and position.
- C. The Contractor shall provide shores and struts with positive means of adjustment capable of taking up formwork settlement during concrete placing operations, using wedges or jacks or a combination thereof. Trussed supports shall be provided when adequate foundations for shores and struts cannot be secured.

- D. The Contractor shall support form facing materials by structural members spaced sufficiently close to prevent deflection. Forms placed in successive units for continuous surfaces shall be fitted to accurate alignment, free from irregularities, and within allowable tolerances.
- E. Design joints in forms to remain watertight and withstand placing pressures without bulging outward or creating surface patterns. Do not use formwork that leaks mortar.
- F. Where poor formwork is used and finish obtained is less than specified, upgrade finish to an acceptable finish at no additional cost.
- G. Panel Deflections: Limit as required to achieve tolerances specified herein.
- H. For circular structures, forms shall conform to circular shape of structure. Straight panels may be substituted for circular forms if they do not exceed 2 feet in width and in addition to the requirement each panel does not provide an angular deflection more than $3\frac{1}{2}$ degrees per joint, and do not conflict otherwise with these Specifications and/or Drawings.
- I. Design shall account for tolerances, form ties, finishes, architectural features, rebar supports, construction joint locations, and other nonstructural formwork requirements specified.
- J. Design formwork strong enough to hold high liquid heads without form distortion and to meet tolerances as specified herein. Coordinate form design with admixture company information and concrete slump.
- K. Structurally design forms, falsework, shoring, and other structural formwork and meet applicable safety regulations, current OSHA regulations, and other codes.
- L. A licensed engineer shall prepare formwork, falsework, and shoring designs to meet these Specifications and to meet all federal and state requirements.
- M. Meet applicable portions of ACI 347, ACI 318 current edition, and these Specifications.

2.5 REINFORCING SPACERS AND REBAR SUPPORTS

- A. Columns:
 - 1. Provide a positive spacer between column reinforcing and column forms to ensure adequate cover.
 - 2. Remove spacer as concrete is placed, consolidated, and proper support and spacing is achieved.
- B. Walls:
 - 1. Provide positive spacers or chairs specifically designed for wall forms to hold forms and reinforcing at correct dimensions and clearances.

2. Remove spacer or chair if not designed to remain in place as concrete is placed, consolidated, and proper support and spacing is achieved.

PART 3 EXECUTION

3.1 FORM CONSTRUCTION

- A. General: The Contractor shall construct forms complying with ACI Standards 318 and 347, to the exact sizes, shapes, lines, and dimensions shown, and as required to obtain accurate alignment, location, grades, level and plumb work in finish structures. All necessary detail work, construction aids, and embedded items shall be provided as required.
- B. The Contractor shall fabricate forms for easy removal without hammering or prying against concrete surfaces. Crush plates or wrecking plates shall be provided where stripping may damage cast concrete surfaces. Kerf wood inserts shall be provided for forming keyways, reglets, recesses, chamfers and the like, to prevent swelling and assure ease of removal.
- C. Forms for Exposed Concrete:
 1. The Contractor shall drill forms to suit the ties used and to prevent leakage of concrete mortar around the tie holes. The Contractor shall not splinter forms by driving ties through improperly prepared holes.
 2. The Contractor shall not use metal cover plates for patching holes or defects in forms.
 3. The Contractor shall provide sharp, clean corners at intersecting planes, without visible edges or offsets. Back joints with extra studs or girts to maintain true, square intersections shall be provided.
 4. The Contractor shall use extra studs, walers, and bracing to prevent bowing of forms between studs and to avoid bowed appearance in concrete. Narrow strips of form material which will allow the forms to bow shall not be used.
 5. The Contractor shall assemble forms so that they may be readily removed without damage to exposed concrete surfaces.
 6. The Contractor shall place carefully and accurately all bracing to prevent sagging or misalignment.
 7. All forms shall be new or in first class condition free from holes, indentations, or irregular surfaces.
 8. The exposed concrete joints shall be formed with special care to assure proper alignment and uniform cross section.
 9. The Contractor shall form molding shapes, recesses and projections with smooth finish materials, and install these in the forms with sealed joints to prevent displacement. .

10. The bottom of wall forms that rest on concrete footings or slabs shall be provided with a gasket to prevent loss of fines and paste during placement and vibration of concrete. Such gasket may be a 1- to 1-1/2 inch diameter polyethylene rod held in position to the underside of the form.

D. Cleaning and Tightening:

1. The Contractor shall thoroughly clean forms and adjacent surfaces to receive concrete. All chips, wood sawdust, dirt, or other debris shall be removed just before concrete is to be placed. All forms shall be re-tightened immediately after concrete placement as required to eliminate leaks.

3.3 FORM COATINGS

A. The Contractor shall coat the contact surfaces of forms with form-coating compound before steel reinforcement is placed. No form coating shall be allowed on steel reinforcement or on previously cast concrete sections which abut the new concrete pour.

- B. The Contractor shall thin form-coating compounds only with the thinning agent of type and in amount and under the conditions recommended by the coating compound manufacturer. Excess form-coating material shall not be allowed to accumulate in the forms or to come into contact with concrete surfaces against which fresh concrete will be placed. All form coatings shall be applied in compliance with the manufacturer's instructions.

- C. Steel forms shall be coated with a non-staining, rust-preventative form oil or otherwise to protect against rusting. Rust-stained steel formwork will not be accepted. Coat contact surfaces of forms with a light uniform film (a coverage rate of 1,200 square feet per gallon or higher) of the surface consolidation agent. Apply to steel forms as soon as they are cleaned to prevent discoloration of concrete form rust. Do not get surface consolidation agent on concrete surfaces or reinforcing steel against which fresh concrete will be placed.

3.4 INSTALLATION OF EMBEDDED ITEMS

- A. General: Set and build into the work anchorage devices and other embedded items required for other work that is attached to, or supported by, cast-in-place concrete. Use setting drawings, diagrams, instructions, and directions provided by suppliers of the items to be attached thereto. Securely anchor embedded items to prevent displacement during placement of concrete.

B. Edge Forms and Screed Strips for Slabs:

1. The edge forms or bulkheads and intermediate screed strips for slabs shall be set to obtain the required elevations and contours in the finished slab surface. The Contractor shall provide and secure units to support the types of screeds required.

3.5 BEVELED EDGES (CHAMFER)

- A. Form 3/4-inch bevels at concrete edges, unless otherwise shown.
- B. Where beveled edges on existing adjacent structures are other than 3/4 inch, obtain Engineer's approval of size prior to placement of bevel form strip.

3.6 REMOVAL OF FORMS

- A. General: Formwork not supporting concrete, such as sides of walls, and similar parts of the work, may be removed after cumulatively curing at not less than 50 degrees Fahrenheit for 24 hours after placing concrete, provided; (1) concrete strength is sufficient to withstand damage by form removal operation and the forces acting on it, and (2) that curing and protection operations are maintained.
- B. Formwork supporting the weight of concrete, such as slabs and other structural elements, may not be removed in less than 14 days, and not until the concrete has attained the minimum 28-day compressive strength as indicated by field cured test cylinders taken from that placement.
- C. Contractor shall assume responsibility for damage resulting from improper and premature removal of forms.
- D. Satisfy applicable OSHA requirements with regard to safety of personnel and property.
- E. Do not remove supports and reshore prior to obtaining adequate field cured cylinder results.

3.7 CONCRETE FINISHES

As specified in Section 03300, CONCRETE.

3.8 BACKFILL AGAINST WALLS

- A. Do not backfill against walls until concrete has obtained compressive strength equal to specified 28-day compressive strength.
- B. Place backfill simultaneously on both sides of wall where required to prevent differential pressures.

3.9 FIELD TESTS

- A. Wall Finish Tolerances: Test for compliance with tolerances as specified.
- B. Slab Finish Tolerances and Slope Tolerances:
 - 1. Floor flatness measurements will be made the day after floor is finished and before shoring is removed, to eliminate effect of shrinkage, curling, and deflection.
 - 2. Support 10-foot long straightedge at each end with steel gauge blocks of thicknesses equal to specified tolerance.

3. Compliance with designated limits in four of five consecutive measurements is satisfactory unless obvious faults are observed.
 4. A check for adequate slope and drainage will also be made to confirm compliance with these Specifications.
- C. Finish Tolerance Failures: Repair or replace concrete as specified in Section 03300, CONCRETE.

3.10 REUSE OF FORMS

- A. All forms to be reused shall be clean and surfaces repaired to be reused in following work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable. The Contractor shall apply new form-coating compound material to concrete contact surfaces as specified for new formwork.
- B. When forms are extended for successive concrete placement, the Contractor shall thoroughly clean all surfaces, remove fins and laitance, and tighten forms to close all joints. All joints shall be secured and tightened to avoid offsets.

END OF SECTION

SECTION 03200

CONCRETE REINFORCEMENT

PART 1 GENERAL

1.1 WORK INCLUDED

- A. This section includes the fabrication and placement of steel reinforcement for cast-in-place concrete structures, including bars, ties, supports, and welded wire fabric.

1.2 RELATED SECTIONS

- A. Submittals: Section 01300.
- B. Cast-in-Place Concrete: Section 03300.

1.3 QUALITY ASSURANCE

- A. Codes and Standards: The Contractor shall comply with all requirements of the following codes and standards (most recent edition), except as modified herein:
 - 1. American Welding Society, AWS D12.1 "Recommended Practices for Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction."
 - 2. Concrete Reinforcing Steel Institute, "Manual of Standard Practice."
 - 3. American Concrete Institute, ACI 318 "Building Code Requirements for Reinforced Concrete."
 - 4. American Concrete Institute, ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structure."
 - 5. Other References:
 - a. ASTM A82 - Specification for Steel Wire, Plain, for Concrete Reinforcement.
 - b. ASTM A185 - Specification for Welded Wire, Fabric, Plain for Concrete Reinforcement.
 - c. ASTM A615 - Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - d. AASHTO M31- Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - e. AASHTO M32- Cold Drawn Steel Wire for Concrete.
 - f. AASHTO M54- Fabricated Steel Bar or Rod Mats for Concrete Reinforcement.
 - g. AASHTO M55- Welded Steel Wire Fabric for Reinforced Concrete.

1.4 SUBMITTALS

- A. Manufacturer's Data:

The Contractor shall submit the Manufacturer's specifications and installation instructions for all proprietary materials and reinforcement accessories.

B. Shop Drawings:

1. The Contractor shall submit shop drawings for the fabrication, bending, and placement of concrete reinforcement. All work shall comply with the ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures." Submittals shall show bar schedules, stirrup spacing, diagrams of bent bars, arrangements and assemblies.
2. The Contractor shall submit certification of grade, chemical analysis and tensile properties of the steel furnished.
3. Also see Section 01300, SUBMITTALS.

1.5 DELIVERY, HANDLING, AND STORAGE

- A. All steel reinforcement delivered to the project site shall be bundled, tagged, and marked. Metal tags shall be used indicating the bar size, lengths, and other information corresponding to markings shown on placement diagrams in accordance with ACI 315.
- B. The Contractor shall store concrete reinforcement materials at the site in a manner that will prevent damage and accumulation of dirt or excessive rust. Store to prevent contact with the ground. Protect all reinforcement from any contact with oil, grease, or petroleum based products of any kind.

PART 2 PRODUCTS

2.1 MATERIAL REQUIREMENTS

- A. Materials specified in this section which may remain or leave residues on or within the concrete shall be classified as acceptable for potable water use by the Environmental Protection Agency within 30 days of application or use.

2.2 REINFORCING STEEL GRADE

- A. Unless otherwise called for on the Drawings, all reinforcing steel for this project shall conform to ASTM A615 Grade 60, except for #3 stirrups or column ties which shall be Grade 40.
- B. Bar mats shall conform to the requirements of AASHTO M54 (ASTM A82).

2.3 ACCESSORIES

- A. Chairs and spacers shall be metal stock, designed for the purpose intended.
- B. All accessories shall comply with CRSI "Recommended Practice for Placing Bar Supports, Specifications and Nomenclature."
- C. The Contractor shall provide stainless steel accessories for sight-exposed concrete (exterior), and concrete surfaces exposed to moisture or containing water.

- D. Slabs on grade where the base material will not support chairs, provide supports with sand plates, horizontal runners, or concrete blocks to properly locate steel reinforcing in the slab.
- E. Wire-bar type supports shall comply with CRSI recommendations. Wood, brick, or other materials will not be accepted.
- F. Tie wire shall be 16-gauge, black, soft-annealed wire. Tie wire shall not be closer than 1-inch from surface of wall or slab after tying in place.

2.4 SPLICES AND MECHANICAL CONNECTIONS

- A. Metal Sleeve: If used for splice, provide with cast filler metal, capable of developing in tension or compression 125 percent of specified yield strength of the bar, as manufactured by:
 - 1. Erico Products, Inc., Cleveland, OH, Cadweld C-Series.
 - 2. Or equal.
- B. Mechanical Threaded Connections: Metal coupling sleeve with internal threads which engage threaded ends of bars to be spliced, and develops in tension or compression 125 percent of the specified yield strength of the bar, as manufactured by:
 - 1. Erico Products, Inc., Cleveland, OH, Lenton Reinforcing Steel Couplers.
 - 2. Richmond Screw Anchor Co., Inc., Fort Worth, TX, Richmond DB-SAE Dowel Bar Splicers.

2.5 EPOXY GROUT

- A. Epoxy for grouting reinforcing bars and anchor bars shall be specifically formulated to such application for the moisture condition, application temperature and orientation of the hole to be filled. Epoxy grout shall be a two part resin. Epoxy shall meet the minimum requirements of ASTM C – 881 specification for type I, II, IV and V, grade 3, class B, C and D and must develop a minimum 5000 psi compressive strength in 24 hours and 10,000 psi compressive strength after a 7 day cure. No shrinkage shall occur and 4.0 percent expansion is allowed by ASTM C 827. All anchor bolts and rebar required to be set in grout shall use epoxy grout.

PART 3 EXECUTION

3.1 FABRICATION

General: The Contractor shall fabricate reinforcing bars to conform to required shapes and dimensions, with fabrication tolerances complying with CRSI "Manual of Standard Practice" and ACI 301. In case of fabricating errors, the heating, rebending or straightening of reinforcement will not be permitted. Submittals of reinforcement shall be in accordance with Section 01300.

3.2 GENERAL

- A. Meet requirements in the manual titled, "Placing Reinforcing Bars", published by Concrete Reinforcing Steel Institute (CRSI).
- B. Steel reinforcement shall be protected at all times from injury. When placed in the work, it shall be free from dirt, detrimental scale, paint, oil and other foreign substance. When steel reinforcement has detrimental rust, loose scale and dust which is easily removable, it shall be cleaned by a satisfactory method, if approved.
- C. All bars shall be bent cold, unless otherwise permitted. No bars partially embedded in concrete shall be field bent except as shown on the Drawings or otherwise permitted.
- D. Details of concrete reinforcement and accessories not covered herein or on the Drawings shall be in accordance with ACI 315.
- E. Notify Engineer when reinforcing is ready for inspection and allow sufficient time for this inspection prior to close-up of the forming system or placing concrete.

3.3 INSTALLATION

- A. The Contractor shall clean reinforcement to remove all loose rust and mill scale, earth, ice, oil or grease, and other materials which reduce or destroy the bond between the concrete and reinforcing steel.
- B. The Contractor shall position, support, and secure all reinforcement to prevent displacement by formwork, construction loadings, or concrete placement operations. Steel reinforcing shall be located and supported by metal chairs, runners, bolsters, spacers and hangers, as required. Where concrete is to be placed on the ground supporting concrete blocks (or dobies) shall be used in sufficient numbers to support the bars without settlement, but in no case shall such support be continuous. All concrete blocks used to support reinforcement steel shall be tied to the steel with wire ties which are embedded in the blocks. The reinforcement shall be placed to obtain the coverage for concrete protection noted on the Drawings. Where the coverage is not shown, the reinforcement shall be placed to obtain at least the minimum coverage specified hereinafter. The Contractor shall arrange, space, and securely tie bars and bar supports together with 16-gauge wire to hold reinforcement accurately and solidly in position during concrete placement operations. Wire ties shall be set so that the twisted ends are directed away from the exposed concrete surfaces. All reinforcement will be tied and secured in the correct position in the forms before placing concrete. Do not stab reinforcing into fresh placed concrete.
- C. The Contractor shall provide a sufficient number of supports of adequate strength to carry the reinforcement. Reinforcing bars shall not be placed more than 2 inches beyond the last leg of any continuous bar support. Supports shall not be used as bases for runways for concrete conveying equipment and similar construction loads.
- D. Supports or spacers of pebbles, pieces of broken stone, concrete rubble, broken brick or building blocks, metal pipe or wooden blocks will not be permitted.
- E. Splices:
 - 1. Standard reinforcement splices shall be done by lapping the ends, placing the bars in contact, and tightly wiring the splice together. The requirements of ACI 318 for minimum lap of spliced bars shall be provided. Use lap splices unless

otherwise shown on the Drawings or permitted in writing by the Engineer. Stagger splices minimum of 40 bar diameters in adjacent bars unless otherwise shown on the Drawings or permitted in writing by the Engineer.

2. No field welding or tacking of reinforcement will be permitted.
 3. Vertical bars in columns shall be offset at least one bar diameter at lapped splices. To ensure proper placement, templates shall be furnished for all column dowels.
- F. Unless otherwise shown on the Drawings, the Contractor shall provide cover as follows:
1. Not less than 3 inches where the concrete is placed against the ground and without use of forms.
 2. Not less than 3 inches for bars smaller than No. 6 and not less than 2-inches for No. 6 bars and larger where concrete is exposed to the weather, water, or in contact with earth, but placed in forms.
 3. Not less than 1 1/2-inches for interior slabs, walls, beams, and columns.
- G. The Contractor shall provide a minimum of two No. 4 bars in the top and bottom of a slab or wall face at 45 degrees on all four corners at all openings in structural slabs and walls, unless otherwise shown on the Drawings. Bars shall extend on each side sufficiently to develop bond in each bar.
- H. The Contractor shall notify the Engineer when reinforcing is in place so that an inspection of reinforcement placement can be made prior to the close-up of formwork or the placement of concrete.
- I. Conform to ACI 301 for all placing tolerances.
- J. Bars may be moved to avoid interference with other reinforcing steel, conduits, or embedded items. If moved more than one bar diameter or the stipulated tolerance, the Contractor shall consult with the Engineer to determine final placement.
- K. Before constructing concrete form work for next stage of construction, the Contractor shall clean all dowels, reinforcing bars, and concrete surfaces at construction joints. All loose material and foreign objects shall be cleaned out of forms before placement of concrete.
- L. Placing Welded Wire Fabric:
1. Extend fabric to within 2-inches of edges of slab, and slab control joints and lap splices at least 1½ courses of fabric or minimum 8-inches.
 2. Tie laps and splices securely at ends and at least every 24-inches with 16-gauge black annealed steel wire.
 3. Place welded wire fabric on #4 continuous bars at 4'-0" at proper distance above bottom of slab. All slab reinforcing is to be discontinuous at slab control joints.

4. Meet current ACI 318 and current Manual of Standard Practice, Welded Wire Fabric, by the Wire Reinforcement Institute regarding placement, bends, laps, and other requirements.
5. All welded wire fabric shall be provided in flat sheets. Rolled fabric will not be permitted.

M. Field Bending:

1. Straightening and Rebending: Do not straighten or rebend metal reinforcement. Field bending of reinforcing steel bars is not permitted.
2. Unless permitted by Engineer, do not cut reinforcing bars in the field.

3.4 MECHANICAL SPLICES AND CONNECTIONS

- A. Install as required by manufacturer with threads tightened as required by referenced ICBO Report.
- B. Carefully inspect each splice and verify that each component meets manufacturer's and ICBO requirements.
- C. Maintain minimum edge distance and concrete cover.

3.5 EMBEDMENT OF DRILLED REINFORCING STEEL DOWELS

A. Hole Preparation

1. The hole diameter shall be as recommended by the epoxy manufacturer but shall be no larger than 0.25 inch greater than the diameter of the outer surface of the reinforcing bar deformations.
2. The depth of the hole shall be as recommended by the epoxy manufacturer to fully develop the bar but shall not be less than 12 bar diameters unless noted otherwise.
3. The hole shall be drilled by methods which do not interfere with the proper bonding of epoxy.
4. Existing reinforcing steel in the vicinity of proposed holes shall be located prior to drilling. The location of holes to be drilled shall be adjusted to avoid drilling through or nicking any existing reinforcing bars.
5. The hole shall be blown clean with clean, dry compressed air to remove all dust and loose particles.
6. Epoxy shall be injected into the hole through a tube placed to the bottom of the hole. The tube shall be withdrawn as epoxy is placed but kept immersed to prevent formation of air pockets. The hole shall be filled to a depth that insures that excess material will be expelled from the hole during down placement.

7. Dowels shall be twisted during insertion into the partially filled hold so as to guarantee full wetting of the bar surface with epoxy. The bar shall be inserted slowly enough to avoid developing air pockets.

END OF SECTION

SECTION 03251

EXPANSION AND CONSTRUCTION JOINTS

PART 1 GENERAL

1.1 WORK INCLUDED

Work necessary to furnish and install, complete, the expansion, construction, and control joints including premolded, pourable, and gun grade fillers.

1.2 RELATED WORK SPECIFIED UNDER OTHER SECTIONS

- A. Submittals: Section 01300.
- B. Reinforcing Steel: Section 03200.
- C. Concrete and Grout: Section 03300.
- D. Saw-cut Control Joints: Section 03300.

1.3 SUBMITTALS

- A. Product Data: Furnish for the following:
 - 1. Joint fillers for horizontal and sloped joints.
 - 2. Preformed control joints.
 - 3. Water stop.
 - 4. Adhered strip seal.
 - 5. Sealants.
- B. Shop Drawings: Furnish information listed below:
 - 1. Plastic Type Water Stops: Details of construction joint types; show in sufficient detail water stop support used in both concrete pours to demonstrate water stop will remain secure until complete encasement.
 - 2. Construction Joints: Layout and location indicating type to be used.
- C. Quality Control submittals: Furnish the following documents:
 - 1. Water stop manufacturer's written instructions for product shipment, storage, handling, installation and repair.
 - 2. Joint Filler and Primer: Manufacturer's written instructions for product shipment, storage, handling, application, and repair.
 - 3. Adhered strip seal manufacturer's written instructions for product shipment, storage, handling, application, and repair.

4. Submit placement shop drawings showing the location and type of all joints for each structure.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Packing and Shipping: Prepare and protect materials for shipment in accordance with manufacturer's recommendations.
- B. Acceptance at Site: Verify that water stops delivered meet the cross-section dimensions shown and manufacturers reviewed product data prior to unloading and storage at the site.
- C. Protect hydrophilic waterstop from premature exposure to moisture which may cause premature swelling of waterstop. Protect from oil, dirt, and sunlight.

1.5 QUALITY ASSURANCE

- A. Water Stop inspection: It is required that all waterstop field joints shall be subject to rigid inspection, and no such work shall be scheduled or started without having made prior arrangements with the Engineer to provide for the required inspections. Not less than 24 hours notice shall be provided to the engineer for scheduling such inspections
- B. All field joints in waterstops shall be subject to rigid inspection for misalignment, bubbles, inadequate bond porosity, cracks, offsets, and other defects which would reduce the potential resistance of the material to water pressure at any point. All defective joints shall be replaced with material which shall pass said inspection, and all faulty material shall be removed from the site and disposed of by the CONTRACTOR at its own expense.
- C. The following waterstop defects represent a partial list of defects which shall be grounds for rejection:
 1. Offsets at joints greater than 1/16-inch or 15 percent of material thickness, at any point, whichever is less.
 2. Exterior crack at joint, due to incomplete bond, which is deeper than 1/16-inch or 15 percent of material thickness, at any point, whichever is less.
 3. Any combination of offset or exterior crack which will result in a net reduction in the cross section of the waterstop in excess of 1/16-inch or 15 percent of material thickness at any point, whichever is less.
 4. Misalignment of joint which result in misalignment of the waterstop in excess of 1/2 -inch in 10 feet.
 5. Porosity in the welded joint as evidenced by visual inspection.
 6. Bubbles or inadequate bonding which can be detected with a penknife test. (If, while prodding the entire joint with the point of a pen knife, the knife breaks through the outer portion of the weld into a bubble, the joint shall be considered defective.)

- D. Waterstop samples: Prior to use of the waterstop material in the field, a sample of a fabricated mitered cross and a tee constructed of each size or shape of material to be used shall be submitted to the ENGINEER for review. These samples shall be fabricated so that the material and workmanship represent in all respects the fittings to be furnished under this contract. Field samples of fabricated fittings (crosses, tees, etc.) will be selected at random by the ENGINEER for testing by a laboratory at the OWNER's expense. When tested, they shall have a tensile strength across the joints equal to at least 600 psi.
- E. Construction Joint Sealant: The CONTRACTOR shall prepare adhesion and cohesion test specimens as specified herein, at intervals of 5 working days while sealants are being installed.
- F. The sealant material shall show no signs of adhesive or cohesive failure when tested in accordance with the following procedure in laboratory and field tests:
 - 1. Sealant specimen shall be prepared between 2 concrete blocks (1-inch by 2-inch by 3-inch). Spacing between the blocks shall be 1-inch. Coated spacers (2-inch by 1-1/2-inch by 1/2 -inch) shall be used to insure sealant cross-sections of 1/2-inch by 2 inches with a width of 1-inch.
 - 2. Sealant shall be cast and cured according to manufacturer's recommendations except that curing period shall be not less than 24 hours.
 - 3. Following curing period, the gap between blocks shall be widened to 1-1/2-inch. Spacers shall be used to maintain this gap for 24 hours prior to inspection for failure.

1.6 GUARANTEE

- A. The CONTRACTOR shall provide a 5-year written guarantee of the entire sealant installation against faulty and/or incompatible materials and workmanship, together with a statement that it agrees to repair or replace, to the satisfaction of the OWNER, at no additional cost to the OWNER, any such defective areas which become evident within said 5-year guarantee period.

PART 2 PRODUCTS

2.1 GENERAL

- A. All joint material specified herein shall be classified as acceptable for potable water use, by the Environmental Protection Agency, within 30 days of application

2.2 PLASTIC WATER STOP

- A. Extruded from an elastomeric plastic compound of which the basic resin shall be polyvinyl chloride (PVC). Reclaimed PVC in the compound is not acceptable.
- B. Specific Gravity: Approximately 1.37.
- C. Shore Durometer Type A Hardness: 65 to 80.
- D. Performance Requirements: Corps of Engineers' Specification CRD-C572.

- E. Type: Center bulb with a number of parallel ribs or protrusions on each side of strip center.
 - 1. Corrugated or tapered type water stops are not acceptable.
- F. Size: Four-inch with 3/16-inch web, 6-inch or 9-inch with 3/8-inch web. Only use 4-inch size where specifically shown on the Drawings.
- G. Thickness: Constant from bulb edge to the outside stop edge.
- H. Minimum Weight per Foot of Water Stop:
 - 1. 0.90 pounds for 3/16-inch by 4-inch.
 - 2. 1.60 pounds for 3/8-inch by 6-inch.
 - 3. 2.45 pounds for 3/8-inch by 9-inch.
- I. Provide for at all construction, expansion and control joints indicated on the Drawings.
- J. Manufacturers and Catalog Numbers:
 - 1. Vulcan Metal Products, Inc., Construction Materials Division, Birmingham, AL; Catalog No. 3/81-15M: Type 8069 (6-inch by 3/8-inch), and Type 8070 (9-inch by 3/8 inch).
 - 2. Vinylex Corp., Knoxville, TN; Catalog No. 03250/ VIN (1987): No. RB6-38H (6-inch by 3/8-inch) and No. RB9-38H (9-inch by 3/8 inch).
 - 3. Greenstreak Plastic Products, St. Louis, MO; Catalog No. 03250/GRD (1987): Style 732 (6-inch by 3/8-inch) and Style 735 (9-inch by 3/8-inch).
 - 4. A.C. Horn, Inc., Beltsville, MD; Catalog No. CSP-162 (1987): Type 9 (6-inch by 3/8-inch) and Type 10 (3/8-inch by 9-inch).

2.2 WIRE LOOPED PLASTIC WATER STOP

- A. May be provided as an alternative to specified plastic water stops without wire loops.
- B. Comply with hereinbefore specified material and geometry requirements of Article PLASTIC WATER STOP, except as follows:
 - 1. Add continuous galvanized wire looping at plastic water stop edge for convenience in positioning and securing stop in-place in the forms.
- C. Manufacturer and Catalog Numbers:
 - 1. The Schlegel Corp., Rochester, New York; "Wire Stop Water Stop"; geometry numbers 05-151-YACR-4361, 05-151-ACR-6380, 05-151-ACR-

9380 as shown on Schlegel Corp., Drawing No. 05-151-ACR dated 11-30-82.

2. Or equal.

2.3 BOND BREAKER TAPE FOR EXPANSION JOINT

- A. Adhesive-backed glazed butyl or polyethylene tape which will adhere to the premolded joint material or concrete surface.
- B. Width: Same as the joint.
- C. Location: As shown.

2.4 BOND BREAKER

- A. Provide either bond breaker tape as hereinbefore specified or a bond prevention material, nonstaining type, as specified in Section 03300, CONCRETE, except where a tape is specifically called for.

2.5 BACKING ROD

- A. Backing rod shall be an extruded closed-cell, polyethylene foam rod. The material shall be compatible with the joint sealant material used and shall have a tensile strength of not less than 40 psi and a compression deflection of approximately 25 percent at 8 psi. The rod shall be 1.8 inch larger than the joint width except that one-inch diameter rod shall be used for ¾ inch wide joint.

2.6 JOINT FILLER (JF)

- A. Expansion Joints in waterholding structures: Sponge Rubber: Neoprene, closed-cell, expanded; ASTM D1056, Type RE-45-E1, with a compression deflection, 25 percent deflection (limits), 119 to 168 kPa (17 to 24 psi) minimum.
- B. All other applications: Closed-Cell Neoprene: ASTM D1752, Type I; as manufactured by W.R. Meadows, Inc., Elgin, IL; or equal.

2.7 PREFORMED CONTROL JOINT

- A. One-piece, flexible, polyvinyl chloride joint former; Kold-Seal Zip-Per Strip KSF-150-50-50, manufactured by Vinylex Corp., Knoxville, TN; or equal.
- B. One-piece steel strip with preformed groove; Keyed Kold Retained Kap, manufactured by Burke Concrete Accessories, Inc., San Mateo, CA; or equal.
- C. Provide in full-length unspliced pieces.
- D. Provide only where specifically permitted by Drawings.

2.8 JOINT SEALANT

- A. Joint sealant shall be approved for use in potable water supply systems. The specific gravity of the in-place filler after curing shall be greater than 1.0. The

manufacturers of the following fillers shall provide written certification that the products are approved by the EPA and the State Department of Health for use in potable water supply systems, and will not be a hazard to health.

B. Manufacturers and Products:

1. Sikaflex 2C, Colonial White color only, as manufactured by Sika Chemical Company, Lyndhurst, NJ; submit product information for review and acceptance.
2. On sloping joints, use Gun Grade material of the above products of Sikaflex 1A similar nonsag material; submit product information for review and acceptance.
3. Or equal.

2.9 STEEL EXPANSION JOINT DOWELS

- A. Dowels: Round smooth steel bars; ASTM A36.

2.10 PVC TUBING

- A PVC tubing in joint shall be schedule SDR 13.5, conforming to ASTM D2241.

2.10 ACCESSORIES

- A. Joint Sealant: Joint sealant shall be two-part polysulfide or urethane conforming to FS TT-S-00227. The type used shall be specifically intended for exterior, submerged control joint applications. A non-sag joint sealant shall be used for vertical joints and self-leveling for horizontal joints.

B. Nonshrink Grout:

1. As specified in Section 03300, CONCRETE.
2. Compatible with joint sealant.

- D. Reinforcing Steel: As specified in Section 03200, CONCRETE REINFORCEMENT.

2.11 HYDROPHILIC WATERSTOP

- A. Hydrophilic waterstop shall be a non-bentonite modified chloroprene rubber.

B. Manufacturers

1. Greenstreak- Hydrotite
2. Or equal

PART 3 EXECUTION

3.1 GENERAL

- A. Locate joints as shown, or noted on the Drawings.
- B. Verify conformance of water stops with dimensions shown and with reviewed product data prior to embedding water stops in concrete.
- C. Construct straight joints; make vertical or horizontal, except where walls intersect sloping floors.
- D. Commence concrete placement after the joint preparation is complete.
- E. Time Between Concrete Pours:
 - 1. At least 2 hours must elapse after depositing concrete in long or high columns and/or heavy walls before depositing concrete in beams, girders, or slabs supported thereon.
 - 2. For short columns and low height walls, 10 feet or less, wait at least 45 minutes prior to depositing concrete in beams, girders, brackets, column capitals, or slabs supported thereon.
 - 3. Consider beams, girders, brackets, column capitals, and haunches as part of the floor or roof system and place monolithically with the floor or roof system.
 - 4. Should concrete placement sequence result in cold joint located below finished water surface, install water stop in joint prior to additional concrete placement. Notify Engineer prior to installing waterstop. Engineer shall approve preparations prior to concrete placement.

3.2 SURFACE PREPARATION

- A. Construction Joints: Prior to placement of abutting concrete, clean contact surface:
 - 1. Remove laitance and spillage from reinforcing steel and dowels.
 - 2. Roughen surface to a minimum of 1/4-inch amplitude:
 - a. Sandblast after the concrete has fully cured.
 - b. Water blast after the concrete has partially cured.
 - c. Green cut fresh concrete with high pressure water and hand tools.
 - 3. Perform cleaning so as not to damage water stop, if one is present.
- B. Expansion Joint with Joint Sealant:
 - 1. Use motorized wire brush or other motorized device to mechanically roughen and thoroughly clean concrete surfaces on each side of joint from plastic water stop to the top of the joint.

2. Use clean and dry high pressure air to remove dust and foreign material, and dry joint.
3. Prime surfaces before placing joint filler.
4. Avoid damage to water stop.

C. Control Joint:

1. Coat concrete surfaces above and below plastic water stop with bond breaker. Do not allow bond breaker to come in contact with water stop.
2. Avoid damage to water stop.
3. Verify that proper type and size of reinforcing and dowels are provided.

3.3 INSTALLATION OF WATER STOPS

A. General:

1. Join water stops at intersections to provide continuous seal.
2. Center water stop on joint.
3. Secure water stop in correct position to avoid displacement during concrete placement.
4. Repair or replace damaged water stop.
5. Vibrate concrete to obtain impervious concrete in the vicinity of all joints.
6. Joints in Footings and Slabs:
 - a. Ensure that space beneath plastic water stop is completely filled with concrete.
 - b. During concrete placement make a visual inspection of the entire water stop area as shown.
 - c. Limit concrete placement to elevation of water stop in first pass, vibrate the concrete under the water stop, lift the water stop to confirm full consolidation without voids, then place remaining concrete to full height of slab as shown.
 - d. Apply procedure to full length of plastic water stops.

B. Plastic Water Stop: Install in accordance with details shown and manufacturer's written instructions.

C. Hydrophilic Waterstop:

1. Inspect waterstop for premature swelling, discontinuity, and debris contamination prior to concrete placement. Replace unacceptable waterstop.
 2. Adhere waterstop to concrete or other surfaces utilizing proper primer adhesive. For vertical applications, use nails in addition to the primer adhesive to secure waterstop to concrete.
 3. Primer shall be allowed to dry for two hours prior to application of waterstop.
 4. Apply waterstop the same day as primer adhesive.
 5. Protect waterstop from moisture, dirt, oil, and sunlight during the progress of work.
 6. Install waterstop with 2 inches minimum clear cover to concrete face.
 7. Waterstop shall be butt spliced, pressing ends together ensuring no separation or air pockets.
- D. Splices and Joints: In accordance with the water stop manufacturer's written instructions using a thermostat-ically controlled heating iron. Butt splice unless specifically detailed otherwise.
1. Allow at least 10 minutes before the new splice is pulled or strained in any way.
 2. Finished splices shall provide a cross-section that is dense and free of porosity with tensile strength of not less than 80 percent of the unspliced material.

3.4 EXPANSION JOINT INSTALLATION

A. General:

1. Place bond breaker above and below water stop when premolded joint filler and pourable joint filler is not used.
2. Joint Sealant:
 - a. Sufficient in width to completely fill the joint space where shown.
 - b. If a water stop is in the joint, cut premolded joint filler to butt tightly against the water stop and the side forms.
3. Precut premolded joint filler to the required depth, as detailed, at locations where joint filler or sealant is to be applied.
4. Form cavities for joint filler with either precut, premolded joint filler, or smooth removable accurately-shaped material.

5. Vibrate concrete thoroughly along the joint form to produce a dense, smooth surface.

C. Pourable Joint Filler:

1. General: Install in accordance with the manufacturer's written instructions, except as specified below:
 - a. Apply primer prior to pouring joint filler.
 - b. Fill entire joint above the water stop with joint filler as shown.
 - c. Use masking tape on top of slabs at sides of joints; clean all spillage.
2. Place cold-applied, two-component fillers in accordance with manufacturer's written instructions.

D. Steel Expansion Joint Dowels:

1. Install coated bars parallel to wall or slab surface and in true horizontal position perpendicular to the joint in both plan and section views so as to permit joint to expand or contract without bending the dowels.
2. Secure dowels tightly in forms with rigid ties.
3. Install reinforcing steel in the concrete as shown to protect the concrete on each side of the dowels and to resist any forces created by joint movement.

3.5 CONTROL JOINT INSTALLATION

- A. Locate reinforcing and/or dowels as shown.
- B. Install PVC water stop or hydrophilic waterstop as shown as shown by the Drawings.
- C. Concrete surface to be dense and smooth.
- D. Install bond breaker to concrete surfaces above and below water stop.

3.6 PREFORMED CONTROL JOINTS

- A. Use only where specifically shown.
- B. Locate flush, or slightly below the top of slab.
- C. Install in accordance with manufacturer's written instructions in straight, full-length unspliced pieces.
- D. Steel Strip Type with Preformed Groove: Brace to with-stand pressure of concrete during and after placement.

3.7 ADHERED STRIP SEAL

Clean surfaces, place adhesive, and install hypalon strip in accordance with manufacturer's instructions.

END OF SECTION

SECTION 03300

CONCRETE

PART 1 GENERAL

1.1 WORK INCLUDED

- A. This section shall include constructing the cast-in-place concrete structures consisting of Portland cement, fine and coarse aggregate, water and selected admixtures, combined, mixed, transported, placed, finished, and cured as herein specified.
- B. This section also includes grout for miscellaneous uses, surface hardeners, bonding agents, fiber reinforcement, and other related concrete accessories, and construction requirements.
- C. Contractor is responsible to have all cracks in water-bearing structures repaired by the epoxy injection method. The work shall be done by a certified applicator of the epoxy manufacturer.

1.2 RELATED WORK

- A. Submittals: Section 01300.
- B. Quality Control: Section 01400.
- C. Concrete Formwork: Section 03100.
- D. Concrete Reinforcement: Section 03200.
- E. Expansion and Construction Joints: Section 03251.

1.3 QUALITY ASSURANCE

- A. The Contractor shall have available on-site a copy of ACI SP-15 "Specifications for Structural Concrete for Buildings with Selected ACI and ASTM References."
- B. The Contractor shall comply with all requirements of the following codes and standards, except as modified herein:
 - 1. ACI 301 "Recommended Practice for Concrete Inspection."
 - 2. ACI 318 "Building Code Requirements for Reinforced Concrete."
 - 3. ACI 304 "Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete."
 - 4. ACI 305 "Recommended Practice for Hot Weather Concreting."
 - 5. ACI 306 "Recommended Practice for Cold Weather Concreting."

6. ACI 308 "Recommended Practice for Curing Concrete."

C. Other references:

1. ASTM C-31 - Making and Curing Concrete Test Specimens in the Field
2. ASTM C-33 - Specification for Concrete Aggregates
3. ASTM C-94 - Specification for Ready-Mixed Concrete
4. ASTM C-143 - Standard Test Method for Slump of Portland Cement Concrete
5. ASTM C-150 - Specification for Portland Cement
6. ASTM C-260 - Specification for Air-Entraining Admixtures for Concrete
7. ASTM C-309 - Specification for Liquid Membrane-Forming Compounds for Curing
8. ACI 302 - Concrete Floor and Slab Construction
9. ACI 614 - Specification for Concrete Placement

1.4 SUBMITTALS

- A. Refer to Section 01300, SUBMITTALS.
- B. The Contractor shall submit three copies of the manufacturer's data with the application and installation instructions for proprietary materials and items, including reinforcement and forming accessories, admixtures, patching compounds, joint systems, and others as requested by the Engineer.
- C. A concrete placement schedule shall be prepared by the Contractor and submitted to the Engineer for review prior to the start of concrete placement operations.
- D. The Contractor shall furnish copies of the delivery tickets for each load of concrete delivered to the site and other information as specified under ASTM C94, Certification.
- E. Concrete Mix Design Proposals
 1. Concrete Mix: Submit each mix design to the Engineer for review at least 14 days before first use is planned. Include substantiating test data and mix design details, including aggregate gradation and source, water/cement ratio, mix proportions, air content, slump, and strength. Substantiating data must include tests by an independent testing laboratory verifying the requirements specified under "Section 2.01 PROPORTIONING AND DESIGN OF MIXES" and "PART 4 TESTING". Submit complete information for each mix design which has different strength, different aggregate size or gradation, different proportions or is to be transported differently. For previously used mix submit copies of at

least 10 tests meeting these specifications. Do not use any concrete until the mix design and substantiating data for that concrete has been reviewed.

2. Pumped Concrete: At least 14 days before starting work, submit details of proposed pumping operation, equipment to be used, and mix designs. Do not pump concrete if Engineer feels an unsatisfactory concrete may result from the overall planned process and equipment.
- F. To demonstrate their capabilities and experience, provide qualification data for Contractor's proposed independent testing agency that will provide the testing services specified under PART 4 TESTING. Do not use the same agency that provides the mix design proposal specified herein. To qualify for acceptance, the independent testing agency must demonstrate, based on the evaluation criteria in ASTM C1093, that it has the experience and capability to satisfactorily conduct the testing indicated.
 - G. Water-Holding Basin Repair Methods: As necessary, if water holding basins fail leak tests as specified. Cracks shall be repaired by the epoxy injection process.
 - H. Crack Repair Report: Epoxy injection materials manufacturer certification that crack repair was performed by a licensed and certified applicator per the manufacturer's recommendations.
 - I. Wall Finish Mock ups: Provide mock ups of adequate size to show the finished product of a wall form joint and typical wall surface finish for a Smooth Form Finish (Section 3.6.B) and Grout Cleaned Surface (Section 3.6.C).

PART 2 PRODUCTS

2.1 GENERAL

- A. All materials shall be classified as acceptable for potable water use by the Environmental Protection Agency within 30 Days of application.

2.2 PROPORTIONING AND DESIGN OF MIXES

- A. The following mix properties are required for all concrete placement within forms:

1. Proportion and design concrete mixes shall meet the following requirements:

For Concrete Footings, Wall, Slabs, and Foundations:

Strength @ 7 days	2400 psi
Strength @ 28 days	4000 psi
Maximum water/cement ratio	0.45 by weight
Slump @ point of placement	3-5 inches
Entrained Air	4-6%
Maximum Aggregate Size	1½ inch, as defined below, unless otherwise shown on the Drawings.

Concrete Thrust Blocking:

Strength @ 7 days	1800 psi
Strength @ 28 days	3000 psi

Maximum water/cement ratio	0.44 by weight
Slump @ point of placement	3-5 inches
Entrained Air	4-6%
Maximum Aggregate Size	1½ inch, as defined below, unless otherwise shown on the Drawings.

2. Design shall be by an approved independent testing laboratory and a trial mix batch shall be made and tested by that laboratory. Average strength of cylinders in trial batch must exceed specified strength by 15%.
 3. A previously used mix design may be used provided aggregate source is the same, the mixing equipment is the same, and provided at least 10 tests were made by an independent laboratory with results meeting these specifications.
 4. If any of the first three 7-day cylinder tests fail to meet the specified 7-day strength, the mix shall be modified for higher strength. Submit modified mix for review before use.
 5. Adjustment to Concrete Mixes: Mix design adjustments may be requested by the Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, at no additional cost to the Owner. Test data for revised mix designs and strength results must be submitted and accepted before using the mix adjustments.
 6. Entrained Air: Air-entraining admixture shall be used unless otherwise shown or specified. Air-entraining admixture shall be added at the manufacturer's prescribed rate to result in concrete at the point of placement with an air content as specified herein (volume basis).
 7. Concrete shall be mixed in conformance with ASTM C94.
- B. Entrained air admixtures shall be used according to the manufacturer's prescribed rate. Test in accordance with ASTM C231.
- C. The use of an accelerating agent is not permitted unless specifically authorized by the Engineer.
- D. Combined Aggregate Gradings:
1. Aggregate size shall be ¾-inches maximum for all areas or sections, unless otherwise indicated on the Drawings.
 2. Grading limits for course aggregate shall be as follows:

Sieve Size	Percentage Passing		
	1-1/2" Max.	1" Max.	3/4" Max.
2"	-100	--	--
1-1/2"	95-100	-100	--
1"	--	95-100	-100
3/4"	25-60	--	90-100
1/2"	--	25-60	--
3/8"	--	--	40-90
No. 4	0-10	0-10	5-20
No. 8	0-5	0-5	0-5

3. Grading limits for fine aggregates shall be as follows:

Sieve Size	Percentage Passing
3/8"	-100
No. 4"	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10
No. 200	0-4

4. The combined mixture of fine and coarse aggregate shall be such that not more than 1.5 percent passes the No. 200 sieve.

2.3 PORTLAND CEMENT

- A. Meet ASTM C150, Type I or Type I-II (sulphate resistant) or Type I-III (low alkali), including low alkali provisions of Table 2 of that specification.
- B. Nonhydraulic Above-Grade Structures: Use either Type I or Type II cement.
- C. Hydraulic and Below-Grade Structures: Use Type I-II (sulphate resistant) or Type I-III (low alkali) cement.

2.4 AGGREGATES

- A. Fine: Clean, sharp, natural sand, ASTM C 33. Fineness modulus shall not be less than 2.5 nor more than 3.0. Materials passing 200 sieve shall be 4 percent maximum.
- B. Coarse: Crushed stone or gravel, ASTM C 33. Maximum size of coarse aggregate shall be $\frac{3}{4}$ -inches as defined hereinbefore, unless otherwise indicated on the Drawings. Materials passing 200 sieve shall be 0.5 percent maximum.
- C. Aggregates shall be natural, free from deleterious coatings, meeting ASTM C 33, nonreactive. Thoroughly and uniformly wash before use. In accordance with ASTM C 33, Appendix XI, paragraph X1.1, evidence of reactive problems on existing structures will be used to prove sources of aggregates are reactive and are unsuitable for use in the work. Import nonreactive aggregates if local aggregates are reactive. Import aggregates if local aggregates and concrete produces shrinkage volume changes in excess of specified amount.
- D. Local aggregates, including the alkali reactive fine aggregate (Birdsall Blunt sand), are acceptable with the exception that they can only be used with Dakotah Cement Type I-IIIA and Type F Flyash added, as specified.
- E. Local aggregates not in compliance with the soundness and durability requirements of this standard shall not be used except with prior written approval of the Engineer and provided it can be shown by special testing or a record of past performance that these aggregates produce concrete of adequate strength and durability. Aggregate soundness testing for fine and coarse aggregates shall be in accordance with ASTM C 88 using a sodium sulfate solution.

2.5 WATER

All water for concrete mixtures shall be clean, potable, and free from injurious substances and conforming to ASTM C 94. Water containing 2 percent or more common salt shall not be used and chloride levels shall be less than 500 parts per million.

2.6 AIR ENTRAINING ADMIXTURES

- A. Air entraining admixtures shall be used in all concrete exposed to the weather and as specified for quality of concrete used, ASTM C 260, except that admixture shall be non-toxic after 30 days and contain no chlorides or other chemicals causing corrosion.
 - 1. "Aerolith," Sonneborn Building Products, Inc.
 - 2. "MB-VR," Master Builders Company.
 - 3. "Sika-AER," Sika Chemical Corp.

4. "Darex AEA," W.R. Grace and Company.
 5. "Protex," Protex Industries, Inc.
- B. Must be compatible with water-reducing admixture. Concrete with air-entrainment admixture added shall maintain air percentage as batched, within 2 percent for minimum 1 ½ hours after addition to concrete mix and through concrete pumping.

2.7 WATER-REDUCING ADMIXTURES

- A. Water-reducing admixtures shall conform to ASTM C494, Type A or Type D.
- B. Complex, multi-component, nonchloride, noncorrosive admixture providing unique performance qualities unobtainable from conventional water-reducing admixtures.
- C. Manufacturer and Product:
1. Master Builders, Inc., Cleveland, OH, Pozzolith or Pozzolith Polyheed.
 2. W.R. Grace & Co., Cambridge, MA, WRDA-79.
- D. Must be compatible with air entraining admixture.

2.8 SUPERPLASTICIZERS

- A. Meet ASTM C494 and use only Type F or G, of second or third generation type.
- B. Hold slump of 5 inches or greater for the time required for placement into structure, or 2 hours minimum.
- C. Type F Superplasticizer: Batch plant added to extend plasticity time, control temperature of fresh concrete, reduce water 20 to 30 percent, and give higher strengths at all ages.
- D. Type G Superplasticizer: Batch plant added to extend plasticity time, maintain setting characteristics similar to normal concrete throughout its recommended dosage range and at varying concrete temperatures, reduce water 30 to 40 percent, and give high-early and ultimate strengths.
- E. Superplasticizers for Hot Weather Placements:
1. A synthesized sulfonated complex polymer type superplasticizer containing no chlorides or alkalines.
 2. Add to mix at manufacturer's recommended dosage to allow placement with concrete temperatures up to 90 degrees F.

F. Manufacturer and Product:

1. Master Builders, Inc., Cleveland, Ohio, Rheobuild or Pozzolith Polyheed at a dosage greater than 10 ounces per 100 pounds of cement.
2. W.R. Grace & Co., Cambridge, Maine, Daracem 100.
3. Euclid Chemical Co., Cleveland, Ohio, Eucon Super F or 537G.

2.9 FLY ASH

- A. Fly Ash shall not be used.

2.10 CALCIUM CHLORIDE

- A. Calcium chloride and products containing more than 0.1% chloride ions are not permitted. Provide admixture manufacturer's written certification that chloride ion content complies with specified requirements.

2.11 FREEZE PROTECTION ADMIXTURE

- A. ASTM C494 Type E admixture, specially formulated to provide protection from freezing down to 20 degrees F. (-7 degrees C.) until initial set has been reached.
- B. Manufacturer and Product:
1. Master Builders Co., Pozzutec 20.
 2. Or equal.

2.12 CONCRETE CURING MATERIALS

- A. Do not use curing compound where additional finishes such as hardeners, paintings, and other special coatings are required. Use water curing as specified instead.
- B. Absorptive cover shall be provided by burlap cloth made from jute or kenaf, weighing approximately 9 ounces per square yard and complying with AASHTO M 182, Class 2.
- C. A moisture retaining cover shall comply with one of the following:
1. Waterproof paper, ASTM C 171 or AASHTO M 171.
 2. Polyethylene film, ASTM C 171.
 3. Curing Compound: Resin based compound conforming to ASTM C 309, with additional requirement that the moisture loss shall not exceed 0.030 gm/square cm/72 hours.

- D. Manufacturer's certification shall state that curing compound can be applied in one coat and shall show the quantity or coverage required to meet or exceed that above moisture retention.
- E. Provide manufacturer's certification that curing compound is acceptable to the appropriate state agency or health department.

2.13 PATCHING CONCRETE

- A. Patching concrete may use the same materials and proportions as the concrete except:
 - 1. The coarse aggregate shall be omitted.
 - 2. No more than one part cement to 2-1/2 parts sand by loose volume shall be used.
 - 3. The Contractor shall prepare a trial patch-mix for the Engineer's approval prior to patching. A white Portland cement shall be used if necessary to produce the color to match the surrounding concrete.

2.14 CRACK REPAIR EPOXY

- A. SCB Process by Adhesive Engineering Co., San Carlos, CA
- B. Two-component epoxy injection by Sika Chemical Corp., Lyndhurst, NJ
- C. Or equal.

2.15 NON-SHRINK GROUT

- A. Nonshrink Grout Category I:
 - 1. Nonshrink, nonmetallic, nongas-liberating grout for use in filling tie holes in concrete, blockouts for gate guides, joints of precast components or members, and grouting baseplates of columns that do not exceed one story in height shall be one of the following:
 - a. Crystex, L&M Construction Chemicals, Inc., Omaha, NE
 - b. EUCO NS grout, Euclid Chemical Co., Cleveland, OH
 - c. Five Star Special 100, U.S. Grout Corp., Fairfield, CT
 - d. SET nonshrink grout, Master Builders Co., Cleveland, OH
 - e. Supreme grout, Gifford Hill & Co., Dallas, TX

- f. UPCON "Super Flow", UPCO Co., Cleveland, OH
 - 2. All grout shall be a fluid consistency in use except that for formwork tie holes the grout shall be dry pack consistency and shall fill the conical section with dense grout hammered in with steel tool and steel hammer.
 - 3. Use Category II type grout for filling through-bolt openings as hereinafter specified.
 - 4. Use Category II grouts for patching defects in walls and slabs after form removal.
- B. Nonshrink Grout Category II:
- 1. Nonshrink grout with natural aggregate for use in high strength, precision support of machine bases of 25 hp or less; bases for precast wall sections, columns, and precast members more than one story in height; filling of through-bolt openings in concrete walls; and patching defects in walls and slabs after form removal shall conform to the Corps of Engineers' Specification for Non-Shrink Grout, CRD-C261-81 and to these specifications. Fluid grout as determined by the flow cone, CRD-C611-81, shall have a minimum strength of 4,800 psi at 7 days and 6,800 psi at 28 days as determined by CRD-C227. The following listed grouts are acceptable for use as Category II grout (field test requirement shall be met):
 - a. Conbextra High Flow, Fosroc, Twinsburg, OH
 - b. Five Star Special 100, U.S. Grout Corp., Fairfield, CT
 - c. EUCO NS Grout, Euclid Chemical Co., Cleveland, OH
 - d. Master Flow 713, Master Builders, Cleveland, OH
 - e. Supreme grout, Gifford Hill & Co., Dallas, TX
 - f. UPCON "Super Flow", UPCO Division, Cleveland, OH
 - 2. No material other than water shall be added to the premixed grout at the jobsite. Follow manufacturer's instructions relative to mixing, placing, and curing.
- C. Nonshrink Grout Category III:

1. Nonshrink grout for use in high strength, precision support of machine bases for machinery of 30 hp or greater and soleplates where very large loads and stresses from vibration and other dynamic loads are involved and when the equipment will be subject to thermal movements. The following grouts are acceptable for use as Category III grout (field test requirements shall be met):
 - a. Embeco 636, Master Builders, Cleveland, OH
 - b. Conbextra High Flow, Fosroc, Twinsburg, OH
 - c. EUCO Hi-Mod grout, Euclid Chemical Co., Cleveland, OH
 - d. CRYSTEX, L&M Construction Chemicals, Inc., Omaha, NE
2. The location for use, other than that specified above, shall be as shown on the Drawings and/or as specified hereinafter.
3. The grout shall be free of gas-producing or gas-releasing agents, free of oxidizing catalysts, free of inorganic accelerators, and free of chlorides. Provide performance characteristics when mixed to fluid consistency, 22 to 25 seconds (flow cone method, CRD-C 611-80) as follows:
 - a. When mixed and maintained at 45 degrees F (7 degrees C) or higher, no visible bleeding and/or settlement up to 2 hours on ½ gallon grout poured into gallon can, covered with glass plate to prevent evaporation.
 - b. Grout shall be cured in accordance with grout manufacturer's instructions.
 - c. Provide (2" x 2" cube) strengths as specified. Prepare specimens and test in accordance with ASTM C 109-80 except as follows: Mix grout in accordance with manufacturer's instructions. Fill molds in two layers, puddling each layer gently with gloved finger five times; strike off excess grout; wipe edges of mold clean with rag and cover with steel plate clamped to mold until time to test. Seal cover 24 hours after placement.
4. The grout shall obtain a minimum compressive cube strength of 5,000 psi at 7 days and 9,000 psi at 28 days (2-inch cubes).

2.16 GROUT FOR HORIZONTAL CONSTRUCTION JOINTS IN WALLS

Neat cement grout shall be flowable and shall consist of sand, water, and a minimum of 12 sacks of cement per cubic yard. Provide positive measuring device such as a bucket or other device that will contain only enough grout for depositing in one place in the wall to ensure that any one portion of the form does not receive too much grout. The depositing of grout from pump hoses or large concrete buckets will not be permitted,

unless inspection windows close to the joint are available to allow visual measurement of grout thickness and means for grout removal are available for removal of excess grout. Refer to PART 3 EXECUTION portion of these Specifications for other requirements.

2.17 SURFACE HARDENER

- A. Surface hardeners shall consist of a colorless aqueous solution of sodium silicate and magnesium and zinc fluosilicates suitable for application to cured or partially cured concrete surfaces and capable of reacting with the soluble calcium compounds present in the concrete to form a thin surface of increased hardness with reduced potential for dusting.
- B. Approved proprietary hardeners include:
 - 1. Saniseal 100, Master Builders Company.
 - 2. Hornolith, A.C. Horn Incorporated.
 - 3. Lapidolith, Sonneborn Company.
 - 4. Pena-Lith, W.R. Meadows Incorporated.
- C. The solution shall be delivered ready for use at the job site.

2.18 CONTROL JOINT FORMS

Control Joint Forms: A standard manufacturer's item causing a control joint in the slab while providing keying across the joint. It shall not leave any portion projecting at the finished surface and it shall interrupt at least 1/4 of the slab depth. The joint or the method of installation shall insure a straight joint deviating not more than 1/2-inch from a straight line.

2.19 EPOXY BONDING AGENT

- A. Two component material suitable for use on dry or damp surfaces. Provide material "Type", "Grade", and "Class", to suit project requirements. Meet the requirements of ASTM C 881.
- B. Products: Subject to compliance with requirements, provide one of the following:
 - 1. Edoco 2118 Epoxy Adhesive; Edoco Technical Prod.
 - 2. Sikadur Hi-Mod; Sika Chemical Corp.
 - 3. Euco Epoxy 463 or 615; Euclid Chemical Corp.
 - 4. Patch and Bond Epoxy; The Burke Co.

PART 3 EXECUTION

3.1 CONCRETE MIXING

- A. The materials for concrete shall be mixed at an acceptable concrete batch plant. Meet ACI 304 current edition and other requirements as specified for mix design, testing, and quality control.
- B. Ready-mix concrete shall comply with the requirements of ASTM C94 and as herein specified:
 - 1. The addition of water to the mix at project site must be approved by the Engineer and the maximum water-cement ratio shall not be exceeded. The delivery ticket shall be noted with amount of additional water added and submitted to the Engineer.
 - 2. Concrete shall be discharged at the job within 1-1/2 hours after water has been added to the cement and aggregates or cement batched with the aggregates, unless a longer time is specifically authorized by the Engineer.
 - 3. During hot weather or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C94 may be required:
 - a. When the air temperature is between 85 degrees Fahrenheit and 90 degrees Fahrenheit, the mixing and delivery time shall be reduced from a maximum of 1-1/2 hours to 75 minutes and when the air temperature is above 90 degrees Fahrenheit, the mixing and delivery time shall be reduced to no more than 60 minutes.
- C. Truck Mixers:
 - 1. Equip with electrically actuated counters to readily verify the number of revolutions of the drum or blades.
 - 2. Counter:
 - a. Resettable, recording type, mounted in driver's cab.
 - b. Actuated at time of starting mixers at mixing speeds.
 - 3. Performance Requirements:
 - a. Truck mixer operation shall provide a concrete batch as discharged within acceptable limits of uniformity with respect to consistency, mix and grading.
 - b. If slump tests taken at approximately the 1/4 and 3/4 points of the load during discharge give slumps differing by more than 1 inch when specified slump is 3 inches or less, or differing by more than

2 inches when specified slump is more than 3 inches, discontinue use of truck mixer unless causing condition is corrected and satisfactory performance is verified by additional slump tests.

- c. Check mechanical details of mixer, such as water measuring, and discharge apparatus, condition of blades, speed of rotation, general mechanical condition of unit, and clearance of drum before attempting to reuse unit.

- 4. Do not use nonagitating or combination truck and trailer equipment for transporting ready-mixed concrete.

D. Mixing Process:

- 1. Concrete Volume in Truck:
 - a. Limit to 63 percent of total volume capacity per ASTM C94 when truck mixed.
 - b. Limit to 80 percent of total volume capacity when central mixed.
- 2. Mix each batch of concrete in truck mixer for minimum 70 revolutions of drum or blades at rate of rotation designated by equipment manufacturer as mixing speed.
- 3. Perform additional mixing, if required, at speed designated by equipment manufacturer as agitating speed.
- 4. Place materials, including mixing water, in mixer drum before actuating the revolution counter for determining the number of mixing revolutions.

3.2 PREPARATION

A. Pre-Placement Inspection:

- 1. Before placing concrete, the Contractor will inspect and complete the formwork installation, placement of reinforcing steel, and items to be embedded or cast-in. Reinforcing shall not be stabbed into freshly placed concrete.
- 2. The wood forms shall be wetted immediately before placing the concrete when form coatings are not used. Dampen subgrade before placing concrete for slabs on grade unless a vapor barrier is used.
- 3. The installation of joint materials shall be coordinated with the placement of forms and reinforcing steel.
- 4. Secure reinforcement in position and allow Engineer to review acceptability before placing concrete.

- B. Sleeves, Anchors and Inserts: All sleeves, anchors, and inserts required shall be properly placed, as detailed in the Drawings, in the concrete formwork and securely anchored to prevent displacement during the placing of the concrete.
- C. Removal of water: Remove all water from space which concrete is to be placed.

3.3 CONCRETE PLACEMENT

- A. Concrete shall be placed in compliance with the practices and recommendations of ACI Standards 304, 318, and 614, and as herein specified:
 - 1. Concrete shall be placed continuously or in layers of such thickness that no concrete will be placed on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness within the section. If a section cannot be placed continuously, the Contractor shall provide construction joints as specified in Section 03251, EXPANSION AND CONSTRUCTION JOINTS. The placement of concrete shall be done at such a rate that concrete is still workable. Concrete shall be placed as near as practicable to its final location to prevent segregation due to rehandling or flowing. Do not subject concrete to any procedure which will cause segregation.
 - 2. Screed concrete which is to receive other construction to the proper level to avoid excessive skimming or grouting.
 - 3. Concrete which has become non-plastic and unworkable, or does not meet the required quality control limits, or which has been contaminated by foreign material shall not be used. Do not use retempered concrete. Remove rejected concrete from the project site and dispose of it at an approved location.
 - 4. Concrete discharge time shall be less than 90 minutes after adding cement to water and aggregate.
- B. Placing Concrete into Forms:
 - 1. Concrete shall be placed in forms in horizontal layers not deeper than 24 inches and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer while the preceding layer is still workable to avoid cold joints.
 - 2. Temporary spreaders in forms shall be removed when concrete placement has reached the elevation of such spreaders.
 - 3. Concrete placed in forms shall be consolidated by mechanical vibrating equipment supplemented by hand-spading, rodding, and tamping. Use equipment and procedures for consolidation of concrete in accordance with the recommended practices of ACI 309, to suit the type of concrete and project conditions. Vibration of forms and reinforcing will not be permitted.

4. Vibrators shall not be used to transport concrete inside of the forms. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than the visible effectiveness of the machine. Place vibrators to rapidly penetrate the layer of concrete and at least 6 inches into the preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion, limit the duration of the vibration to the time necessary to consolidate the concrete and complete embedment of reinforcement and other embedded items without causing segregation of the mix. Generally, this will be from 5 to 15 seconds in accordance with ACI 301.
 5. Allowable Vertical Free Fall Drop to Final Placement:
 - a. 5 feet in forms 8-inch or less wide, and 8 feet in forms wider than 8 inches, except as hereinafter specified.
 - b. Superplasticized Mixes: Up to 15 feet, if slump is over 6-inches.
 6. Do not use aluminum pipe or other aluminum conveying devices.
 7. Provide sufficient illumination for interior of forms so concrete at places of deposit is visible to permit confirmation of consolidation quality.
- C. Conveyor Belts and Chutes:
1. Design and arrange ends of chutes, hopper gates, and other points of concrete discharge throughout conveying, hoisting, and placing system such that concrete passing from them will not become segregated.
 2. Do not use chutes longer than 50 feet.
 3. Minimum Slopes of Chutes: Angled to allow concrete of specified consistency to readily flow without segregation.
 4. Conveyor Belts:
 - a. Approved by Engineer.
 - b. Wipe clean with a device which does not allow mortar adhering to the belt to be wasted.
 - c. Cover conveyor belts and chutes.
- D. Retempering: For concrete or mortar in which cement has partially hydrated, retempering is not permitted.
- E. Pumping of Concrete:
1. General:

- a. Pumping is the preferred method of placing concrete.
- b. If pumped concrete does not produce satisfactory end results, discontinue pumping operation until the problem is corrected.
- c. At Contractor's option, other approved methods of placement may be used.

2. Equipment:

- a. Provide standby pump, conveyor system, crane and concrete bucket, or other system acceptable to Engineer, on site during pumping, for adequate redundancy to assure completion of concrete placement without cold joints in case of a primary placing equipment breakdown.
- b. Minimum Pump Hose (Conduit) Diameter: 4 inches.
- c. Replace pumping equipment and hoses (conduits) that are not functioning properly.
- d. Do not use aluminum conduits for conveying concrete.

3. Field Control (For Pumped Concrete): Take concrete samples for slump (ASTM C143) and test cylinders (ASTM C31 and C39) and shrinkage specimens (ASTM C157) at placement (discharge) end of line.

F. Consolidation and Visual Observation:

1. Consolidate concrete with internal vibrators with minimum frequency of 8,000 vpm and amplitude required to consolidate concrete in section being placed.
2. Provide at least one standby vibrator in operable condition at placement site prior to placing concrete.
3. Consolidation equipment and methods shall meet ACI 309.
4. Provide sufficient windows in the forms or limit form height to allow visual observation of concrete.
5. Vibrator operator shall be required to see concrete being consolidated to ensure good quality workmanship, or an individual shall actually observe the vibration of concrete at all times and advise vibrator operator of any changes needed to ensure complete consolidation.
6. Consolidation and placement locations shall be planned and accomplished so that vibrators shall be inserted in the concrete as it is

placed and in locations not to exceed a distance of 5 feet from point of placement.

G. Placing Concrete Slabs:

1. Prior to concrete placing, any area of subgrade on which concrete is to be placed shall be properly wetted. Concrete slabs shall be placed in a continuous operation, within the limits of construction joints, until the placement of a panel or section is completed. When in-place concrete has sufficiently set up (at least 24 hours), an alternate section shall be placed. All joints between sections shall be properly keyed. The edges of all sections shall be tooled with a minimum radius or chamfer edging tool.
2. Concrete shall be consolidated during placement operations using vibrating equipment, so that the concrete is thoroughly worked around reinforcement and other embedded items and into the corners.
3. Slab surfaces shall be brought up to the correct level with a straightedge and struck off. Bull floats or darbies may be used to smooth the surface, leaving it free from humps or hollows. Do not sprinkle water on the plastic surface. Do not disturb the slab surfaces prior to beginning finishing operations.
4. Control Joints for Slabs on Grade:
 - a. Locate as shown on the Drawings. Where not indicated, locate at 13 foot maximum intervals in both directions.
 - b. Construct with a manufactured, embedded control joint form or stop pour at each control joint using keyway forms and place concrete in checkerboard pattern with no two adjacent panels placed on the same day. Install form with no offsets and in straight lines as specified elsewhere.
 - c. Sawn control joints will be permitted. Saw joint 1½-inches deep, or 1/4 slab thickness, whichever is greater. Start sawing within 12-hours of placement but delay as necessary to prevent raveling.
5. Reinforcing steel shall be continuously maintained in the proper position during concrete placement operations.
6. All exterior concrete slabs shall be sloped in a manner to prevent the collection of water.

I. Bonding:

1. Surfaces of set concrete at all joints shall be roughened, except where bonding is obtained by use of an approved concrete bonding agent, and the surfaces shall be cleaned of laitance coating, loose particles, and foreign matter. Surfaces shall be roughened in a manner to expose bonded aggregate uniformly and laitance, loose particles of aggregates, or damaged concrete at the surface shall be removed.
2. Bonding of fresh concrete to new concrete that has set, but is less than 60 days old or is not fully cured shall be done as follows:
 - a. At joints between a footing and walls or columns, and between walls or columns and beams or slabs that they support, and elsewhere unless otherwise specified herein, dampen, but do not saturate, the roughened and cleaned surface of set concrete immediately before placing the fresh concrete.
 - b. At vertical joints in exposed work, and at joints designed to contain liquids, dampen, but do not saturate, the roughened and cleaned surface of set concrete.
 - c. Neat cement grout as specified hereinbefore shall be applied to a minimum thickness of 2 inches. Fresh concrete shall be placed before the cement grout has attained its initial set. Limit concrete lift placed immediately on top of grout to 12 inches.
 - d. An approved commercial bonding agent may be used in lieu of neat cement grout. The agent shall be applied to cleaned concrete surfaces in accordance with the printed instruction of the bonding agent manufacturer.
3. Epoxy bonding adhesive shall be applied in accordance with the manufacturer's recommendations for bonding to old concrete (more than 60 days old). Coat contact surfaces with bonding agent after mechanically roughening surface to a clean, rough surface.

J. Cold Weather Placing:

1. All concrete work shall be protected from physical damage or reduced strength which could be caused by freezing or low temperatures, in compliance with the requirements of ACI 306 and ACI 318 and as herein specified.
2. When the temperature of the surrounding air is expected to be below 40 degrees Fahrenheit during concrete placement or within 3 days (72 hours) thereafter, the temperature of the placed concrete shall be maintained at temperatures no lower than 60 degrees Fahrenheit for sections less than 12 inches in any dimension or 55 degrees for any other

section. Heated water and/or aggregate shall be used in accordance with ACI 306.

- a. The placed concrete temperature shall be maintained at or above the specified temperatures for curing for at least 7 days.
3. Frozen concrete materials containing ice or snow shall not be used. Concrete shall not be placed on frozen subgrade or on subgrade containing frozen materials. The Contractor shall determine that the forms, reinforcing steel, and adjacent concrete surfaces are entirely free of frost, snow, and ice before placing any concrete.
4. The use of calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators shall not be allowed, unless authorized in writing by the Engineer.
5. Maintain temperature of concrete above 50 degrees for a minimum of 7 days.
6. Strength requirements may require additional protection and curing during cold weather due to delayed field strength gain.
7. Determine strength attainment, and the requirement for continue protection, from field test cylinders, cured along side the cast concrete structure.
8. Surface Temperature:
 - a. The actual temperature of concrete surface determines effectiveness of protection, regardless of air temperatures or whether the objective is durability or strength.
 - b. Provide a sufficient number of thermometers placed on concrete surfaces spaced throughout the work to allow inspection and monitoring of concrete surface temperatures representative of all the work.
9. External Heating Units:
 - a. Vent heating units and do not locally heat or dry concrete.
 - b. Do not exhaust flue gases directly into an enclosed area.
 - c. Ensure fire safety and fire prevention measures are enforced during use of heating units.
10. Maintain curing conditions which will foster normal strength development without excessive heat, and without critical saturation of concrete at the close of the protection period.

11. Limit rapid temperature changes, particularly before strength has developed sufficiently to withstand temperature stresses.
12. At end of the required period, discontinue protection in such a manner that the drop in temperature of any portion of concrete will be gradual and will not exceed, in 24 hours, 50 degrees F.

K. Hot Weather Placing:

1. When hot weather conditions exist that would seriously impair the quality and strength of concrete, place concrete in compliance with ACI 305 and as herein specified.
2. The ingredients shall be cooled before mixing to maintain the concrete temperatures at the time of placement below 80 degrees Fahrenheit. Mixing water may be chilled or chopped ice may be used.
3. Reinforcing steel may be covered with watersoaked burlap if it becomes too hot, so that the steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.
4. The use of retarding admixtures will not be allowed, unless otherwise accepted in mix designs by the Engineer.
5. The forms shall be thoroughly wetted before placement of concrete. Make provisions for windbreaks, shading, fog sprays, sprinkling, or wet cover, when necessary.
6. Reflective Cracking:
 - a. Prevent reflective cracking due to differential temperatures between concrete and reinforcing steel.
 - b. If reinforcement is in direct sunlight or is more than 20 degrees F higher in temperature than concrete temperature before placement, wet reinforcement to cool it with water fog spray 10 minutes before placing concrete.
 - c. Verify temperature of reinforcing is not more than 20 degrees F higher than fresh concrete.

3.4 ORDER OF PLACING CONCRETE

- A. The order of placing concrete in all parts of the Work shall be acceptable to the engineer. In order to minimize the effects of shrinkage, the concrete shall be placed in units as bounded by construction joints at the indicated locations. The placing of unit shall be done by placing **alternate** units in a manner such that each unit placed shall have cured at least 5 days for hydraulic structure and 2

days for all other structure before the contiguous unit or units are placed, except that the corner sections of vertical walls shall not be placed until the 2 adjacent wall panels have cured at least 10 days for hydraulic structures and 4 days for all other structures

- B. The surface of the concrete shall be level whenever run of concrete is stopped to insure a level straight joint on the exposed surface of walls, a wood strip at least $\frac{3}{4}$ inch thick shall be tacked to the form on these surfaces. The concrete shall be carried about $\frac{1}{2}$ inch above the underside of the strip. About one hour after the concrete is placed, the strip shall be removed and any irregularities in the edge formed by the strip shall be leveled with a trowel and all laitance shall be removed.

3.5 JOINTS

A. Construction Joints:

- 1. Construction joints shall be located and installed as shown on the Drawings in a manner that will not impair the strength and appearance of the structure. Construction joints, if not shown, shall be located only with approval of the Engineer and as follows:
 - a. The Contractor shall provide key-ways at least 1-1/2 inch deep in all construction joints in walls, slabs, and between walls and footings.
 - b. Construction joints shall be placed perpendicular to the main reinforcement and all reinforcement shall continue across construction joints.
 - c. Construction joints shall be prepared as specified in ACI Standard 318.

- B. Expansion joints shall be located as shown on the Drawings. Expansion joints shall be held down to receive the joint sealant. The horizontal and vertical waterstop shall be welded together to provide a continuous watertight seal.

- C. For bonding to new concrete horizontal construction joints, roughen the surface of the hardened concrete. Thoroughly clean and saturate with water, cover the horizontal surfaces only with at least two to three inches of grout, as hereinbefore specified, and immediately place concrete. New concrete is defined as less than 60 days old. Limit the concrete lift placed immediately on top of the grout to 12-inches thick and thoroughly vibrate to mix and consolidate the grout and concrete together.

- D. Also see Section 03251, EXPANSION AND CONSTRUCTION JOINTS.

3.6 FINISH OF FORMED SURFACES

A. Rough Form Finish:

1. This finish shall include formed concrete surfaces buried from view by backfill in the finish work or covered by other construction, unless otherwise shown or specified. Any surface which will be exposed to the air in the completed structure shall be a smooth form finish.
2. The standard rough form finish shall leave the concrete surface with the texture imparted by the form facing material used, with tie holes and defective areas repaired and patched and all fins and other projections exceeding 1/4 inch in height rubbed down or chipped off.
3. Fill snap-tie holes with nonshrink, non-metallic grout. Patch honeycomb areas and rock pockets. Small air holes do not require patching.

B. Smooth Form Finish (trowel finish):

1. This finish includes formed concrete surfaces which will be exposed to the air in the completed structure or to be covered with a coating material applied directly to the concrete, or a covering material bonded to the concrete, such as water proofing, damp-proofing, painting, or other similar system.
2. A smooth form finish shall be provided by selecting form materials that will impart a smooth, hard, uniform texture and arranging them orderly and symmetrically with a minimum of seams. All defective areas shall be patched and repaired with all fins or other projections completely removed and smoothed.
3. For smooth form finish walls:
 - a. Fill snap-tie holes with approved nonshrink, nonmetallic color matched grout.
 - b. Grind off projections, fins, and rough spots.
 - c. Repair other defects such as honeycomb areas, rock pockets, and rough spots resulting from form release agent failure or other reason with color matched nonshrink grout.
4. For smooth form trowel finish slabs:
 - a. Finish by screeding and floating with straightedges to bring surface to required finish elevation shown.

- b. While concrete is still green, but sufficiently hardened to bear a person's weight without deep imprint, wood float to true, even plane with no coarse aggregate visible.
- c. Use sufficient pressure on wood floats to bring moisture to surface.
- d. After surface moisture has disappeared, hand trowel concrete to produce smooth, impervious surface, free from trowel marks.
- e. Burnish surface with an additional troweling. Final troweling shall produce a ringing sound from trowel.
- f. Do not use dry cement or additional water during troweling. No excessive troweling will be permitted.
- g. Power Finishing:
 - 1. An approved power machine may be used in lieu of hand finishing for finishing concrete floors and slabs in accordance with directions of machine manufacturer.
 - 2. Do not use power machine when concrete has not attained the necessary set to allow finishing without introducing high and low spots in slab.
 - 3. Do first steel troweling for slab by hand.

C. Grout Cleaned Finish (sacked rubbed finish):

- 1. A grout cleaned finish will be applied to all concrete surfaces as specified hereinafter which have received smooth form finish treatment except at raceway locations.
- 2. The grout cleaned finish will use one part portland cement to 1-1/2 parts fine sand by volume, and shall be mixed with water to a consistency of thick paint. Proprietary additives may be used at the Contractor's option. Standard portland cement and white portland cement amounts shall be blended as determined by trial patches, so that final color of dry grout will match adjacent surfaces.
- 3. The concrete surfaces shall be thoroughly wetted before the application of grout to the surfaces and to fill small holes. Excess grout will be removed by scraping and rubbing with clean burlap.

D. Broomed Finish:

- 1. Finish as specified for trowel floor finish, except omit final troweling and finish surface by drawing a fine-hair broom lightly across the surface.

2. Brooming: In same direction and parallel to expansion joints, or, in the case of inclined slabs, perpendicular to slope, except for round roof slab, broom surface in radial direction.
- E. Sidewalk Finish:
1. Slope walks down ¼ inch per foot away from structures, unless otherwise shown.
 2. Strike off surface by means of strike board and float with wood or cork float to a true plane, then flat steel trowel before brooming.
 3. Broom surface at right angles to direction of traffic.
 4. Lay out sidewalk surfaces in blocks with an approved grooving tool as shown or as directed by Engineer.
- F. Rough Slab Finish:
1. Finish by screeding and floating with straightedges to bring surface to required finish elevation shown.
 2. While concrete is still green and capable of supporting a person's weight without leaving a deep imprint, stamp slab with a gandy or other similar imprinting tool to a depth of 1/4"-3/8".
- G. Related Unformed Surfaces:
1. At horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces, the placed concrete shall be struck off smooth and finished with a texture matching the adjacent formed surfaces. Continue the final surface treatment of the formed surfaces uniformly across the adjacent unformed surfaces, unless otherwise shown on the Drawings.
- H. A 3/4-inch chamfer shall be provided at the top of all exposed walls, except where support angles are installed, and at exposed vertical corners.
- I. In addition to the description of various finishes above, concrete surfaces shall be finished in accordance with ACI Standards 301 and 302 as scheduled below:

<u>Surface</u>	<u>Finish</u>
Interior Slabs	Smooth Trowel Finish
Exterior Slabs	Broom Finish
Exterior Concrete Above Grade, Interior Walls and Ceilings	Rubbed Finish
Exterior Concrete Below Grade	Rough Form Finish

Sidewalks
Raceway Slab
Raceway Walls
Stilling Basin Walls
Stilling Basin Slab

Sidewalk Finish
Smooth Trowel Finish
Smooth form Finish
Rough form Finish
Rough Slab Finish

3.6 CONCRETE CURING AND PROTECTION

A. General:

1. Freshly placed concrete shall be protected from premature drying and excessive cold or hot temperature, and maintained without drying at a relatively constant temperature for the 7 day period of time necessary for the proper hydration of the cement. Concrete damaged by improper curing or placement methods shall be replaced by the Contractor and at no additional expense to the Owner.
2. Curing procedures shall begin immediately after placement of the concrete and continue for at least seven days or until concrete has attained 75 percent of its compressive strength in accordance with ACI 308.

B. Curing Method:

1. Liquid membrane curing shall be provided as follows:
 - a. The Contractor shall use a commercially produced liquid membrane forming curing compound for curing concrete which meets the requirements of ASTM C309.
 - b. Apply the specified membrane-forming curing compound to damp concrete surfaces as soon as the water film has disappeared. Apply uniformly in a 2-coat continuous operation by power spray equipment in accordance with the manufacturer's directions. Re-coat all areas which are subjected to heavy rainfall within 3 hours after initial application. Maintain the continuity of the coating and repair any damage to the coat during the entire 7 day curing period.
 - c. Membrane compounds shall not be used on surfaces which are to be covered with a coating material applied directly to the concrete or with a covering material bonded to the concrete, such as other concrete, liquid floor hardener, waterproofing, damp-proofing, flooring, paintings, and other coatings and finish materials.
2. Use approved water curing method where membrane compounds are not allowed.

3. For walls, use one of the following curing methods:
 - a. Method 1: Leave concrete forms in place and keep entire exposed surfaces wet at all times.
 - b. Method 2: Apply specified curing compound as specified, where allowed, immediately after removal of forms. Apply curing compound in two coats. Each coat shall be applied at the manufacturers recommended rate for one coat application.
 - c. Method 3: Continuously sprinkle 100 percent of all exposed surfaces.
4. For slabs, curbs, and sidewalks use one of the following curing methods:
 - a. Method 1: Protect surface by ponding.
 - b. Method 2: Cover with burlap or cotton mats and keep continuously wet.
 - c. Method 3: Cover with 1-inch layer of wet sand, earth, or sawdust, and keep continuously wet.
 - d. Method 4: Continuously sprinkle exposed surface.
 - e. Other agreed upon method that will provide moisture to be present and uniform at all times on all surface of slabs.
- C. Unformed surfaces shall be cured after finishing operations have been completed and as soon as marring of the concrete will not occur. The curing procedures shall continue for 7 days or until the concrete has attained 70 percent of its compressive strength in accordance with ACI 308.
- D. Temperature of Concrete During Curing:
 1. When the atmospheric temperature is 40 degrees Fahrenheit and below, the concrete temperature shall be maintained between 50 and 70 degrees Fahrenheit continuously throughout the 7 day curing period. When necessary, the Contractor shall make arrangements before the placement of concrete for heating, covering, insulation or housing as required to maintain the specified temperature and moisture conditions continuously throughout the concrete curing period. Cold weather protections shall comply with the requirements of ACI 306.
 - a. Where water curing as specified herein for slabs is not possible, use an approved curing compound as herein specified at twice the manufacturer's recommended coverage per gallon.

- b. Where specified curing compound cannot be used, special methods using moisture shall be agreed upon prior to pouring the concrete slabs.
 - c. Protect slabs during cold weather with polyethylene sheeting or other material inside required heated enclosure if foot traffic is permitted on slabs.
- 2. When the atmospheric temperature is 80 degrees Fahrenheit and above, or during other climatic conditions which will cause a rapid drying of the concrete, the Contractor shall make arrangements before the start of concrete placement for the installation of wind breaks or shading, and for fog spraying, wet sprinkling, or a moisture-retaining covering. The concrete shall be protected continuously for the 7 day concrete-curing period. Hot weather concrete protection shall comply with the requirements of ACI 305.
- 3. The concrete temperature shall be maintained as uniformly as possible, and protected from rapid atmospheric temperature changes. Temperature changes in concrete which exceed 5 degrees Fahrenheit in any one hour and 50 degrees Fahrenheit in any 24-hour period shall be avoided and protected against.
- E. During the curing period the concrete shall be protected from damaging mechanical disturbances including load stresses, excessive vibration and from damage caused by rain or flowing water. All finished concrete surfaces shall be protected from damage by subsequent construction operations. Any damage incurred shall be repaired by the Contractor at no additional expense to the Owner.

3.7 CONCRETE REPAIRS

- A. Cracks in waterholding structures that are determined to have caused excessive leakage or damp spots, or if seepage is present on exposed surfaces:
 - 1. Epoxy inject all cracks with a two component epoxy as specified hereinbefore. Crack repairs shall be performed by a licensed applicator as specified/hereinbefore.
- B. Defective surface areas shall be repaired and patched with grout immediately after removal of forms and as directed by the Engineer.
- C. Repair of Formed Surfaces:
 - 1. Formed surfaces which will be exposed-to-view or air in the completed structure and contain defects which adversely affect the appearance of the finish shall be repaired. The concrete with the defective surfaces shall be removed and replaced at no additional expense to the Owner if

the defects cannot be repaired to the satisfaction of the Engineer. Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, and holes left by rods and bolts, fins, and other discolorations that cannot be removed by cleaning.

2. Concealed formed concrete surfaces that contain defects that adversely affect the durability of the concrete shall be repaired. If defects cannot be repaired, the defective concrete shall be removed and replaced at no additional expense to the Owner.

D. Repair of Unformed Surfaces:

1. Unformed surfaces such as monolithic slabs may be tested by the Engineer for smoothness and to verify that the surface planeness meets the tolerances specified for each surface and finish. Any low and high areas shall be repaired by the Contractor at no additional expense to the Owner as specified herein.
2. Unformed surfaces that contain defects which adversely affect the durability of the concrete shall be repaired. Surface defects include crazing, cracks in excess of 0.01 inch in width or which penetrate to the reinforcement or completely through non-reinforced sections regardless of width, spalling, popouts, honeycomb, rock pockets, and other objectionable conditions.
3. High areas in unformed surfaces shall be repaired by grinding after the concrete has cured sufficiently so that repairs can be made without any damage to adjacent areas.
4. Low areas in unformed surfaces shall be repaired during, or immediately after, completion of surface finishing operations by cutting out the low areas and replacing with fresh concrete. The repaired areas shall be finished to blend into adjacent concrete. Proprietary patching compounds may be used when approved by the Engineer.
5. Defective areas, except random cracks and single holes not exceeding 1-inch diameter shall be repaired, by cutting the area out and placing fresh concrete. Defective areas shall be removed to sound concrete with clean, square cuts, and shall expose reinforcing steel with at least 3/4-inch clearance all around. Concrete surfaces in contact with patching concrete shall be dampened and brushed with a neat cement grout coating or approved epoxy adhesive, or a concrete of the same type or class as the original adjacent concrete. Place, compact, and finish as required to blend with the adjacent finished concrete. The repaired area shall be cured in the same manner as adjacent concrete.

6. Isolated random cracks and single holes not over 1 inch in diameter shall be repaired by the dry-pack method. Groove the top of cracks, and cut out holes to sound concrete. Clean off all dust, dirt, and loose particles. Dampen all cleaned concrete surfaces and apply by brush a neat grout coating. Place dry-pack before the cement grout takes its initial set. Mix dry-pack, consisting of one part Portland cement to 2-1/2 parts fine aggregate passing a No. 16 mesh sieve, using only enough water as required for handling and placing. Compact the dry-pack mixture in place and finish to match the adjacent concrete. Keep the patched areas continuously moist for not less than 72 hours.
7. Repair methods not specified above may only be used if approved by the Engineer.

3.8 SURFACE HARDENERS

- A. Interior slabs shall receive an application of surface hardener as recommended by the manufacturer of the surface hardener.
- B. Floors to receive hardener shall be thoroughly cured for at least 28 days, clean, unpainted, free from membrane curing compounds, and perfectly dry with all work above them completed. Apply liquid hardener evenly, using three coats, allowing 24 hours between coats. The first coat shall be 1/3 strength, second coat 1/2 strength, and third coat 2/3 strength, mix with water. Each coat shall be applied so as to remain wet on the concrete surface for 15 minutes. Apply approved proprietary hardeners in conformance with the manufacturer's instructions. After the final coat is completed and dry, remove surplus hardener from the surface by scrubbing and mopping with water.

3.9 CLEANING AND DISINFECTION OF STRUCTURES

- A. All structures shall be free of debris and material at substantial completion. Pressure washing of all structures is required.
- B. Disinfection. No disinfection of the placed concrete is necessary.

3.10 MISCELLANEOUS CONCRETE ITEMS

- A. Equipment Bases and Foundations: Provide machine and equipment bases and foundations, as shown on Drawings. Set anchor bolts for machines and equipment to template at correct elevations, complying with certified diagrams or templates or manufacturer furnishing machines and equipment.
- B. Grout base plates and foundations as indicated, using specified non-shrink grout. Use non-metallic grout for exposed conditions, unless otherwise indicated. Block out the original concrete or finish off a sufficient distance below the bottom of the machinery base to provide for the thickness of grout shown on the Drawings.

After the machinery has been set in position and wedged to the proper elevation by steel wedges, the space between the bottom of the machinery base and the original pour of concrete shall be filled with a pourable nonshrinking type grout as hereinbefore specified.

3.11 REJECTIONS

- A. Concrete Strength: Concrete strength shall be considered satisfactory if the average test of the two 28-day specimens exceeds the specified strength and neither specimen test falls below 95% of the specified strength. If the average strength of the two test specimens is less than specified and either specimen test is less than 95% of the specified strength, the concrete represented by the tests is rejected and must be removed and replaced at the Contractor's expense.
- B. Alignment: Where concrete slabs or walls do not meet the alignment requirements, the Contractor must grind off irregularities until they comply. However, if such removal leaves less concrete section than indicated, the Engineer may reject concrete if he feels the remaining section would not be adequate.
- C. Flatwork: Finished flatwork exceeding the tolerances of these specifications shall be repaired or replaced so that strength or appearance is not adversely affected. Follow paragraph 3.07 for repair work or as directed by Engineer.
- D. Appearance: Concrete exposed to view with defects which adversely affect the appearance of the specified finish may be repaired, if possible in accordance with paragraph 3.07. If, in the opinion of the Engineer, the defects cannot be repaired to equal the specified finish, the concrete shall be rejected.
- E. Misplaced Members: Concrete members cast in the wrong location may be rejected if the strength, appearance, or function of the structure is adversely affected or misplaced items interfere with other construction.
- F. Rejected Concrete: Rejected concrete shall be removed and replaced. Limits of removal shall be as directed by the Engineer to accomplish a structure equal in strength, serviceability, and appearance, to that which would have been achieved by acceptable concrete.
- G. Expense of Repairs: The cost of all repairs, removal, replacement, etc., required by the provisions of this Article shall be borne by the Contractor.

PART 4 TESTING

4.1 TESTS OF AGGREGATE

- A. Provide tests of aggregate before concreting per ASTM C33. Tests may be waived by Engineer if aggregates to be used have shown actual use to produce

concrete of required strength, durability, water-tightness, fire resistance, and wearing qualities. See Section 2.03 for additional information concerning local aggregates.

4.2 STRENGTH TEST OF CYLINDERS DURING WORK

- A. Provide for test purposes, sets of four cylinders each, taken for each 40 cubic yards or portions placed each day. Test one cylinder per set at 7 days, two at 28 days, and retain one for backup.
- B. Evaluation will be in accordance with ACI Standard Building Code Requirements for Reinforced Concrete (ACI 318-83), Section 4.7, "Evaluation and Acceptance of Concrete", and these Specifications. Where the term "building official" is used in Section 4.7 of ACI 318-83, term shall be redefined to "the Owner's representative".
- C. Specimens will be made, cured, and tested by the Contractor's independent testing firm in accordance with ASTM C31 and ASTM C39.
- D. Frequency of testing may be increased at discretion of Engineer.
- E. Cold Weather Placement Tests:
 - 1. During cold weather concreting, Contractor's independent testing firm will cast cylinders for field curing as follows. Use method which will produce greater number of specimens:
 - a. Six extra test cylinders from the last 100 cubic yards of concrete.
 - b. Minimum three specimens for each 2 hours of placing time or for each 100 yards.
 - 2. These specimens shall be in addition to those cast by Contractor for lab testing.
 - 3. Protect test cylinders from the weather until they can be placed under same protection provided for the parts of the structure which they represent.
 - 4. Keep field test cylinders in same protective environment as the parts of the structure they represent, to determine if specified strength has been obtained and no further protection is needed.
 - 5. Test cylinders in accordance with applicable sections of ASTM C31 and C39.
 - 6. Evaluation and Acceptance: As specified herein.

4.3 SLUMP TESTS

- A. Take slump tests with each strength test and as directed in accordance with ASTM C143.

4.4 AIR CONTENT

- A. ASTM C 173, volumetric method for lightweight or normal weight concrete; ASTM C 231, pressure method for normal weight concrete; one for each day's pour of each type of air-entrained concrete.

4.5 CONCRETE TEMPERATURE

- A. ASTM C1064; one test hourly when air temperature is 40 degrees F and below and when 80 degrees F and above, and one test for each set of compressive strength specimens.

4.6 TEST OF HARDENED CONCRETE

- A. Acceptance shall be based on concrete cylinder tests in accordance with Paragraph 3.11. Contractor may provide additional test by coring per ASTM C42 or load tests for that portion of job where questionable concrete has been placed. Such additional testing will be accepted in lieu of cylinder tests. Results of rebound hammer tests will not be accepted except in defining problem areas.

4.7 TESTING AGENCY

- A. All tests shall be made by an independent testing laboratory approved by the Engineer.

4.8 COST OF TESTING

- A. The Owner shall bear all costs of testing required by this section including tests of hardened concrete where cylinder strengths indicate high or low strength concrete. If additional tests are required above those listed herein, due to low strength concrete or other reasons at fault by the contractor, the contractor shall bear the expense of additional testing.

4.9 TEST RESULTS

- A. Submit two (2) copies of all tests to Engineer within 24 hours of testing.

4.10 CURE BOX

- A. The testing agency shall provide a cure box at the project site for initial cure of test cylinders. Construct and equip box to provide initial cure in accordance with ASTM C31.

END OF SECTION

SECTION 03400
PRECAST CONCRETE

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Precast concrete manhole sections, precast boxes, precast vaults, precast tanks, precast concrete lids, manhole frame, and covers.

1.2 SUBMITTALS

- A. Submit under provisions of Section 01300.
- B. Submit manufacturer's product data and installation data in compliance with Section 01300.

PART 2 - PRODUCTS

2.1 PRECAST MANHOLE SECTIONS

- A. Conform to ASTM C-478 with a minimum wall thickness of 6 inches for 72-inch diameter manhole sections and 8 inches for 96-inch diameter manhole sections.

2.2 MANHOLE GASKETS

- A. Conform to ASTM C-443, ASTM C-428.

2.3 GROUT

- A. Conform to Section 04100 of these Technical Specifications.

2.4 FRAME AND COVER

- A. Standard traffic rated frame and grate or manhole cover if required on the Plans (see Standard Details).

2.5 MANHOLE LID

- A. Flat top lid with diameter as shown on the plans rated for H-20 traffic loading with hatches and/or frame and cover cast in top slab (coordinate opening location and size with pump manufacturer).

- B. Lid shall be a flat top 8-foot 9-inch diameter lid or sufficient cover precast sections with 36" diameter opening (coordinate opening location and orientation with pump manufacturer) rated for H-20 traffic loading plus dead load of 8-foot diameter manhole section and lid above.

2.6 PRECAST VAULTS / TANKS / MANHOLE SECTIONS / LIDS

A. Scope

1. Construction shall include manufacture, transportation and installation, as required of precast structures as shown and specified.
2. Manufacturer shall demonstrate a recognized background in precast concrete production, and that he has facilities and personnel required to produce required structures.

B. Shop Drawings

1. The precast manufacturers shall prepare and submit shop drawings in accordance with Section 01300.
2. Shop drawings shall be complete and shall show overall layout, unit locations, fabrication details, reinforcement, connection details, support items, dimensions, and relations to adjacent materials.
3. Manufacturer shall provide design calculations sealed by a Professional Structural Engineer licensed in the State of Utah.

C. Materials

1. Precast/concrete members shall conform to A.C.I. 318 (latest revision) Building Code Requirements for Reinforced Concrete.
2. Prestressing strand shall meet requirements of ASTM A-416 (latest revision).
3. Reinforcing bars shall meet requirements of ASTM A-615 (latest revision).
4. Welded wire mesh shall meet requirements of ASTM A-185 (latest revision).
5. Aggregates shall meet requirements of ASTM C-33 (latest revision).
6. Cement shall meet requirements of ASTM C-150 (latest revision).
7. Concrete for precast members shall have a minimum ultimate compressive strength of 3000 psi at 28 days. The concrete and the equipment producing the concrete for the precast/members shall meet the requirement so ASTM C-94 (latest revision).

D. Casting and Handling

1. Precast structures shall be built to the clear dimensions shown on the construction drawings. The structures shall be designed per AASHTO Specifications to carry an HS20 loading with a maximum cover as shown on the plans. The lateral effective earth pressure shall be 65 PCF.
2. Precast members shall be handled in positions consistent with their shape and design. Members shall be lifted and supported only from support points.
3. All precast structures shall have watertight joints as provided by the manufacturer, and shall be watertight.
4. Clean weld marks, dirt, or blemishes from surface of exposed members.
5. Pipe penetrations shall be Kor 'N' Seal or equal.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify all materials delivered to the site are in compliance with these Specifications.
- B. Verify structure is ready to receive piping.

3.2 INSTALLATION

- A. Install in accordance with the manufacturer's recommendations. Ensure precast sections are plumb and true.
- B. Place and compact one (1) foot of Type A1 aggregate in compliance with Section 02207 and 02223 under the concrete base prior to installation.
- C. Install Cast in Place base per plans if required and Section 03300
- D. Grout pipe entrance and exit openings water tight.
- E. Place and install so no damage is inflicted to the structure, pipe, or valves.
- F. Install so the walls and ceiling are plumb and true to line and grade.
- G. Grout all joints water tight.

END OF SECTION